Results of air quality modeling to examine the status of attainment of PSD Class I sulfur dioxide increments.

(Protocol Results Report)

FINAL

Completed as draft final October 28, 2004

August 18, 2005

Prepared by
North Dakota Department of Health
Environmental Health Section
PO Box 5520
Bismarck, North Dakota 58506-5520

Results of execution of air quality modeling to examine the status of attainment of PSD Class I sulfur dioxide increments.

August 18, 2005

Prepared by
North Dakota Department of Health
Environmental Health Section
PO Box 5520
Bismarck, North Dakota 58506-5520

Points of Contact
Legal –
Lyle G. Witham, Assistant Attorney General
Administrative –
L. David Glatt, Chief of the Environmental Health Section
Terry L. O'Clair, Director of the Division of Air Quality
Technical –
Martin R. Schock, Senior Environmental Scientist

Final.

FOREWORD

This document is a corrected and updated version of "Results of execution of air quality modeling to examine the status of attainment of PSD Class I sulfur dioxide increments" that is dated October 28, 2004. That version is addendum Tab "C"to the draft final version of "North Dakota's SO2 Air Quality Modeling Report," which was presented to EPA in November 2004. The corrections are listed below.

Section 10.2	Table 15 and figure 18 were replaced with data that uses a background sulfur dioxide concentration of 1.5 ug/m3, rather than 1.0 ug/m3, so as to be consistent with pages 20-28 of this report and the text of this section.
Section 10.4	The text of this section has been updated to reflect additional review of literature and model executable codes.
-----------	Corrections to typing, spelling, and wording.

WindLogics, Inc., did complete a report that describes the synoptic and pollutant transport characteristics of raw RUC-2 data from central to western North Dakota during some extended periods of observed sulfur dioxide at monitoring sites. (See pages 8 and 51 of this document.) This report is document number 116 in the hearings' docket.

Table of Contents **Page**

Acknowledgments

Several staff of the North Dakota Department of Health contributed to development of the CALMET and CALPUFF modeling protocol, the preparation of model input data, the execution of theses models, the analysis of ambient sulfur dioxide monitoring data and preparation of this report. These persons are:

Tom Bachman	Senior Environmental Engineer
Steve Weber	Manager – Air Quality Impact Program
Rob White	Environmental Scientist
Dan Harman	Manager – Air Quality Monitoring Program

1.0 Executive summary.

1.1 <u>Background</u>.

This report summarizes the execution of the April 30, 2004, protocol agreed to by the State of North Dakota and the U.S. Environmental Protection Agency pursuant to a Memorandum of Understanding (MOU) reached on February 24, 2004. (Tab "A") The protocol (Tab "B") describes and contains the data inputs for the CALMET and CALPUFF models, sulfur dioxide emission inventories such as source emission rates, locations and stack characteristics, the background concentration for accuracy tests, and the math methods for calculation of sulfur dioxide deterioration. This report contains the results of the execution of the protocol. It assesses the status of deterioration of ambient sulfur dioxide over the federal Clean Air Act's PSD Class I areas in North Dakota and eastern Montana.

This report refers back to and relies on the protocol modeling process and model data inputs. It does not repeat those factors here, but incorporates them by reference, and refers back to them when appropriate.

> The protocol details are in the protocol under Tab "B". The data presentation and discussion in this report refers to information in the protocol, but does not repeat protocol details.

The results from this execution of the protocol indicate:

1) no exceedances of the 3-hour PSD Class I increment in any PSD Class I area;
2) no exceedances of the 24-hour Class I increment at any one receptor in Class I areas when using 2000 and 2001 meteorological data;
3) no exceedances of the 24-hour increment at any one receptor in the Elkhorn Ranch Unit of the Theodore Roosevelt National Park (TRNP), Lostwood Wilderness Area and Montana Class I areas when using 2002 meteorological data; and
4) one or two exceedances of the 24-hour increment at some receptors in the South and North Units of the TRNP when using 2002 meteorological data.

In addition to providing the results of CALMET and CALPUFF modeling under the protocol, this report summarizes modeling of 2002 emissions paired with 2002 meteorology for a model accuracy assessment, and modeling of a 2002-2003 sulfur dioxide emissions inventory to assess compliance with the increment. The 2002-2003 inventory includes the most recent two years for which emissions data are available. NDAC § 33-15-15-01(1)(a)(1).

This report also contains results when 2002 meteorological data are used with 2002-2003 sulfur dioxide emissions data. These results indicate that predicted deterioration of 3-hour and 24-hour ambient sulfur dioxide complies with the respective CAA PSD Class I increments. The North Dakota Department of Health (hereafter department) also modeled the 2002-2003 emissions with 2000 and 2001 meteorological data; but these results are not included in this report. These results also showed compliance with the short-term sulfur dioxide increments.

The department conducted modeling to examine compliance with the PSD Class I increments for sulfur dioxide in the periodic review proceedings in 2002-2003. This additional modeling incorporates discretionary propositions of the MOU as described in "ND's SO2 PSD Air Quality Modeling Report" to which this report is attached. It adopts: 1) verbal comments and suggestions by EPA during the MOU process of finalizing the protocol, which occurred on April 28, 2004; 2) discussions relating to the WindLogics reports under Tab "D"; and 3) ideas generated during a workshop attended by the department and EPA in St Paul on July 13, 2004, and hosted by WindLogics. The protocol also advances comments on prior modeling, information and data found or described in the docket for two department hearings. (See also pages 4 through 6 of the protocol.)

1.2 Summary.

This section summarizes key conclusions reached upon completion of the protocol modeling. It also refers to the North Dakota SO2 PSD Air Quality Modeling Report, the protocol, the protocol results in this report, and various relevant supporting documents.

1. The department executed the CALMET and CALPUFF models as provided by the protocol. (ND Modeling Report § 3.1)

    a. The department did not conduct comprehensive sensitivity tests of values or settings for control file variables or other inputs due to accuracy test results for years 2000 and 2001. (Protocol p. 6) However, the department conducted comparisons of modeled concentrations with monitored concentrations. (Protocol pp. 21-24 (procedure); Protocol Results Report (this report) §§ 5.1, 5.2, 6.2, & 6.3 and referenced graphs in appendices (comparisons)).

2. Surface wind speeds in the ARPS Data Assimilation System (ADAS) enhanced RUC-2 data are highly correlated with NWS surface wind speeds and are not biased high and, so the enhanced RUC-2 data do not cause lower predicted concentrations. (Protocol Results Report § 3.3, WindLogics Report (Tab "D"), and ND modeling Report § 3.6)

3. The department compiled variations of the protocol's current actual emissions for sulfur dioxide, and the CALPUFF model was re-run; as expected, results are sensitive to emission rates. "Actual emissions" is a term defined by federal and State rule – NDAC § 33-15-15-01(1)(a). The department assembled "actual emissions" (ND Modeling Report § 3.4) for each facility for relevant time periods from 2000-2003. The department then modeled the total sulfur dioxide emitted as described below.

   a. Model inputs followed the protocol. However, the Department modeled additional emission inventories for 2002 (to do a model accuracy test for 2002) and 2002-2003. These were completed in addition to the 2000-2001 inventory described in the protocol. (ND Modeling Report §§ 3.4 & 3.5; Protocol Results Report § 6.1 (emissions) and § 6.2 (accuracy testing for 2002)).

   b. Modeling these additional emissions periods involved replacing the 2000-2001 actual emissions with:

      i. Year 2002 emissions (when modeling 2002 meteorological data), because emissions are linked by meteorology to actual observed concentrations at sites of monitors and because emissions during 2002 were less than emissions during 2000-2001. (Protocol Results Report § 6.1)
      ii. 2002-2003 actual emissions (when using 2002 meteorological data). (Protocol Results Report § 9.1)
      iii. Year by year hourly CEM emissions paired with year by year hourly ADAS enhanced RUC-2 data. (Unlike hourly CEM emissions, an actual emissions rate is not time variant and is applied in modeling 24/7 for all input meteorological data.) (Protocol Results Report § 6.3)

4. The department has ten (10) sets of sulfur dioxide monitoring data gathered from four (4) monitoring sites during the three years of meteorology used in the modeling protocol. (Protocol's Appendix H) These ten sets of data are used in model accuracy performance tests. (Protocol Results Report §§ 5.2, 6.2, & 6.3) Monitoring data are also used as reference benchmarks for predicted baseline concentrations used in calculating deterioration. (Protocol Results Report §§ 7.1 & 7.2) These results show:

   a. Twenty four-hour predicted concentrations often occur on days of observed 24-hour concentrations, which is illustrated with time-series plots. (Protocol Results Report § 4.1) However, the largest predicted 24-hour concentrations are about two times greater than time-concurrent observed concentrations when 2000-2001 emissions are modeled. (Protocol Results Report § 10.2, table 14)

b. Many of the largest observed daily averaged concentrations included hours when the concentration was less than 1 part per billion (ppb). (Protocol Results Report § 4.2)

5. The results of accuracy tests, when comparing the 25 largest predicted sulfur dioxide concentrations to the 25 largest observed concentrations, indicate that:

   a. Model accuracy is acceptable when using 2000-2001 actual emissions with 2000 and 2001 meteorological data. (Protocol Results Report §§ 5.2 & 5.3)

   b. Some 24-hour predicted concentrations contain a bias greater than the 24-hour increment when using 2000-2001 actual emissions with 2002 meteorological data. (Protocol Results Report §§ 5.2, 5.3, & 10.1)

   c. Over prediction bias in predicted concentrations decreases about 20 percent when 2000-2001 actual emissions are replaced with 2002 emission rates and when using 2002 meteorological data. (Protocol Results Report §§ 5.2 & 5.3)

   d. Model accuracy does not change appreciably when replacing 2000-2001 actual emissions and 2002 emissions with year by year hourly CEM emissions that are paired year to year with hourly meteorology. (Protocol Results Report §§ 6.1 & 6.2)

6. Averaged accuracy ratios (Protocol Results Report §§ 5.2 , 6.2, & 6.3) obtained from the accuracy tests range from values near 1.0 to a value larger than 2.0. EPA has often cited factors of one-half (0.5) to two (2.0) as an acceptable range for accuracy ratios. (See 40 CFR Part 51, Appendix W, § 10.)

   a. When over prediction bias is larger than 40 percent (accuracy ratios larger than 1.4), the amount of over prediction for 24-hour deterioration can exceed 5 ug/m3, which is the PSD Class I sulfur dioxide 24-hour increment. (Protocol Results Report § 10.1)

   b. The factor of two is not a bright line between acceptable and unacceptable model accuracy. There are no guiding principles for acceptable or unacceptable model accuracy performance. (Protocol Results Report § 6.4)

   c. Model accuracy test results depend on numerous model data inputs, but all year-to-year inputs provided by the protocol remain unchanged except meteorological data and hourly CEM emissions data. Day-to-day and year-to-year variation in regional weather has a profound effect on predicted concentrations and, thus, accuracy ratios. (Protocol Results Report §§ 5.2, 5.3, 6.2, 6.3 & Appendix E)

7. The federal Clean Air Act (CAA) and rules allow one exceedance of PSD short-term sulfur dioxide increments at a receptor each year. (CAA § 163) An exceedance occurs when calculated deterioration using predicted concentrations at a receptor is larger than the increment. Under EPA guidelines and practice, non-attainment of a PSD short-term increment is triggered by a second exceedance at any one receptor among all protocol receptors throughout all Class I areas *during any one year* among all years of protocol input meteorology. (40 CFR Part 51, Appendix W, § 11)

   a. More specifically, the practice does not allow a second exceedance at any receptor during each year of input meteorology. Thus, atypical weather that occurs at a frequency less than once per year can trigger a second exceedance, because three years of input meteorology, per the protocol, are used. (Protocol Results Report §§ 7.0, 7.3 & 8.0)

   b. The current practice for the pass/fail test of attainment of a PSD increment is specified in EPA's Guideline on Air Quality Models (40 CFR 51, Appendix W); this practice is not otherwise specified in the CAA or rule.

8. When following the protocol, computed changes in 3-hour and 24-hour predicted sulfur dioxide concentrations reveal:

   a. No exceedances of the PSD Class I 3-hour increment (25 ug/m3) during 2000, 2001 and 2002. (Protocol Results Report § 8.1)

   b. No exceedances of the PSD Class I 24-hour increment (5 ug/m3) during 2000 and 2001. (Protocol Results Report § 8.1)

   c. Exceedances of the PSD Class I 24-hour increment at most receptors for the South and North Units of TRNP during 2002. No receptor had more than two exceedances. (Protocol Results Report §§ 8.1 & 9.3)

9. When 2000-2001 actual emissions are replaced with 2002-2003 actual emissions and the protocol is followed using that emissions inventory, computed changes in 3-hour and 24-hour predicted sulfur dioxide concentrations reveal:

   a. No exceedances of the PSD Class I 3-hour increment (25 ug/m3) during 2002. (Protocol Results Report § 8.1)

b. No exceedances of the PSD Class I 24-hour increment (5 ug/m3) during 2002. (Protocol Results Report § 8.1)

10. Replacing the 2000-2001 actual emissions of the protocol with 2002-2003 actual emissions when using 2002 meteorological data is appropriate because:

a. NDAC § 33-15-15-01(1)(a)(1) requires two most recent years of data to show increment compliance. (ND Modeling Report § 3.4)

b. The averaged accuracy test ratios using 2000-2001 emissions with 2002 meteorological data are unacceptable. (Protocol Results Report §§ 5.2 & 5.3) The ratios from an accuracy test using 2002 emissions with 2002 meteorological data improved significantly. (Protocol Results Report §§ 6.1, 6.2, & 6.4)

c. The 2002-2003 actual emissions are similar to 2002 emissions. (Protocol Results Report § 6.1)

d. The most recent emissions data, in this case 2002-2003 actual emissions, are needed for any current assessment of sulfur dioxide deterioration. (ND Modeling Report §§ 3.4 & 4.0)

1.3 Results data.

Table 1 provides a summary of the modeled deterioration of ambient sulfur dioxide among all PSD Class I areas when executing the protocol (years 2000 and 2001 only) and when using supplemental sulfur dioxide emissions data (2002 only). The PSD Class I areas are the South (S), North (N), and Elkhorn Ranch Units of the TRNP, the Lostwood Wilderness Area, the Medicine Lake National Wilderness Area and the Ft. Peck Reservation.

The MOU and the protocol specify two options for gauging the deterioration of ambient sulfur dioxide in the Class I areas when tabulating predicted sulfur dioxide concentrations. (ND Modeling Report § 3.8) The options are two methods for calculating deterioration – each with and without the two operating sources granted a Federal Land Manager (FLM) Certification of No Adverse Impact (CONAI). The two methods for calculating deterioration are EPA's current paired-in-space-and-time method and the Alternate paired-in-space-only method.

Table 1. Highest of the highest second highest deterioration in short-term sulfur dioxide concentrations (ug/m3) among all PSD Class I areas.

METHOD of tracking changes in concentrations at a receptor due to changes in emissions after PSD baseline	WITH sources granted FLM CONAI and a PSD increment variance			WITHOUT sources granted FLM CONAI and a PSD increment variance		
Meteorological data	2000 *	2001 *	2002 **	2000 *	2001 *	2002 **
24-hour (PSD increment is 5 ug/m3):						
EPA's paired in space and time	4.4	4.2	4.7	3.7	3.6	4.0
Paired in space only	2.8	1.9	4.9	2.3	1.7	4.4
3-hour (PSD increment is 25 ug/m3):						
EPA's paired in space and time	17.8	14.8	14.9	14.3	14.4	13.9
Paired in space only	12.7	8.8	10.9	11.0	7.0	9.7

* Results for years 2000 and 2001, numbers are based upon the protocol's 2000-2001 actual emissions.
** Results for year 2002, numbers are based upon 2002-2003 actual emissions.

1.4 Class I increment variances.

The largest of contributions – by the two sources that were granted a CONAI by FLMs and PSD Class I increment variances by the department – to predicted deterioration were 0.7 and 3.5 ug/m3 for 24-hour and 3-hour periods, respectively. (See table 1; ND Modeling Report § 3.7 and analysis under Tab "H") These contributions are a small fraction of the secondary Class I incremental margins of 86 (91 – 5) and 300 (325 – 25) ug/m3 for the 24-hour and 3-hour periods, respectively. (See table 2.) Thus, no exceedance of the short-term alternate increments occurred.

Table 2. PSD increments for sulfur dioxide.

	Class I [1]	Alternate Class I [2]
annual arithmetic mean, ug/m3	2	20
24-hour, ug/m3	5	91
3-hour, ug/m3	25	325

[1] NDAC § 33-15-15-01(2.b)
[2] NDAC § 33-15-15-01(4.j)

1.5 Implications for modeling methods.

Generally, the CALMET and CALPUFF models and protocol model inputs are providing predicted concentrations in reasonable agreement with observed concentrations.[1] (See protocol, pages 21-24; Protocol Results Report §§ 6.3 & 6.4 and table 6; ND Modeling Report § 3.4)

1. Because peak sulfur dioxide emission rates, such as allowable or 90th percentile of hourly CEM emissions, are larger than actual emissions and because CALPUFF predicted concentrations increase with increases in emissions, the use of allowable or peak emissions rather than actual emissions would increase accuracy ratios and degrade model accuracy performance. (ND Modeling Report §§ 3.2, 3.3, 3.4, & 3.5)

2. The current recommended practices in modeling air quality include five years of observational meteorological data, or three years of prognostic data. But this modeling exercise illustrates that predicted concentrations using actual emissions are more likely to correspond to actual observed concentrations, because the observed concentrations are linked by local and/or regional weather to emissions; so, this may require modeling of year-to-year concurrent emissions and meteorology for best comparisons between modeled and monitored concentrations. (Protocol Results Report §§ 6.1, 6.2, 6.3, & 10.4)

Because some accuracy ratios, which compare the 25 largest predicted sulfur dioxide concentrations to the 25 largest observed concentrations, are near 1.0 (0.94 to 1.22), any deviation from protocol inputs for future modeling, except current emissions, should be based upon demonstrably improved model data inputs and model treatments of science. Empirical validation allows adjustments through reassessment and confirmation of model outputs with observations. (ND Modeling Report § 3.4)

1. Parts of this report use monitoring data in concert with modeled data to initiate exploration of synoptic weather conditions (calm and stagnant winds) that may be the underlying conditions for model over prediction of actual observed sulfur dioxide concentrations. A professional services contract for an analysis of such synoptic conditions has been developed between the North Dakota Department of Health and WindLogics of St. Paul, Minnesota. Completion of such services is scheduled for mid-December 2004.

[1] Results of model accuracy tests conducted under this protocol are not comparable to results of accuracy tests previously conducted by the department. Previous accuracy tests used the largest 50 predicted and 50 observed concentrations and assumed that the background concentration for sulfur dioxide was 0 ug/m3.

2. This modeling exercise suggests the occurrence of synoptic weather conditions (i.e., calm and stagnant winds) under which the models apparently lack robust treatment of translation of weather data to the grid scale of the models and the advection of the emitted plumes of the sulfur dioxide. (Protocol Results Report §§ 9.1, 9.2, & 10.4) The available annual sets of observed sulfur dioxide concentrations at sites of monitors in western North Dakota provide a future opportunity to evaluate values or settings of select CALMET and CALPUFF control-file input variables. New accuracy tests of new modeling results using adjusted values or settings and/or other input data could be completed to determine whether the accuracy performance of the models can be improved as demonstrated by better agreement between predicted sulfur dioxide concentrations and observed concentrations.

1.6 Recommendations.

1. Refined inventories of source emitted sulfur dioxide related to PSD baseline dates for the northeastern Montana Class I areas are not needed. (See protocol, page 17.) If these inventories are assembled for refined modeling, the inventories should include the Lewis and Clark power plant and the Holly Sugar plant; both plants are located near Sidney, Montana. (See protocol, page 17.)

2. Development of reliable lower sulfur dioxide detection limits on monitors may allow better assessment of the background concentration for modeling and of short-term averaged concentrations. Currently, no procedure exists to gather reliable concentrations at levels less than 1 part per billion. As monitoring technologies advance, additional quality assurance procedures should be developed to examine reliability of concentration data at detection levels below 1 part per billion. Use of such data collected by monitors could then be assessed.

2.0 Purpose of this Report on the Execution of Modeling Protocol.

This report provides relevant details of the department's execution of the modeling protocol. (Tab "B") It also provides the results of air quality modeling conducted under the February 24, 2004, MOU between the State and EPA. (Tab "A")

"North Dakota's SO2 PSD Air Quality Modeling Report," to which this report is attached, summarizes how the MOU was implemented in the protocol, supporting reasons and documentation, and a summary of these modeling results. This report notes or discusses important issues and details raised in implementing the modeling, including such details as:

- NOAA's RUC-2 data and the process for using ADAS to re-introduce hourly NWS wind data into the RUC-2 data (§ 3.2)
- an assessment of the correspondence between the enhanced RUC-2 data and hourly NWS wind speeds at 10 meters AGL to determine whether a wind speed bias existed (§3.3)
- a summary of monitoring and model accuracy tests as used by the department (§§ 4.0 & 5.0)
- a summary of the lower sulfur dioxide emissions trends in 2002 as compared to 2000-2001 and how that impacted modeling accuracy in these modeling runs (§§ 6.0, 9.0 & 10.0)
- a summary of how short-term increment deterioration was calculated using a full sulfur dioxide emissions inventory (§ 7.0)
- the modeling results (§§ 8.0 & 9.0)
- and other relevant supporting information to assist assessment of model performance and the use of actual emissions inventories to determine sulfur dioxide increment consumption in North Dakota (§10.0 and Appendices A-I to this document)

The department conducted this modeling pursuant to the April 30th modeling protocol. (Tab "B") This report does not repeat the discussion of modeling settings and other details provided in the protocol. It does provide additional comments on some issues and also suggests some factors and considerations for future consideration based on what was learned in executing the protocol.

A model accuracy assessment indicated over-prediction issues when higher 2000-2001 emissions were used. So, in addition to modeling the 2000-2001 sulfur dioxide emissions inventory in the protocol, the department modeled "2002 emissions only" to compare model accuracy when 2002 actual emissions were paired with 2002 meteorological data. The department then modeled 2002-2003 sulfur dioxide emissions to assess current compliance with the increment. See "North Dakota's SO2 PSD Air Quality Modeling Report," § 3.4, NDAC § 33-15-15-01(1)(a)(1) and 45 Fed. Reg. 52675, 52,704-705 (August 7, 1980) ("Example of How the ["Actual Emissions"] Definitions Work").

2.1 Source data errata.

All corrections to the April-30th protocol as described in the Foreword to the corrected protocol were implemented. (See also § 2.1 of the Draft Final of this report dated October 28, 2004.)

Sulfur dioxide 2002 emissions, 2002–2003 actual emissions and hourly CEM emissions for years 2000, 2001 and 2002 were also compiled.

2.2 Model sensitivity tests.

Pages 3 and 6 of the protocol indicate that sensitivity or diagnostic tests may be conducted, if warranted, to examine the technical performance of model calculation methods and algorithms. Model sensitivity tests can also be used to refine model input so as to improve agreement between model data and observational data. However, no comprehensive sensitivity or diagnostic tests were conducted. So all values and settings for CALMET or CALPUFF control-file input variables for all model runs followed the protocol as provided on pages 7 through 15.

3.0 Enhanced RUC-2 weather data.

The magnitude and timing of observed and predicted sulfur dioxide concentrations depend on the temporal sequence and spatial variation of meteorological conditions preceding and during concentration averaging periods as well as the locations and sulfur dioxide emissions of sources.

3.1 Observed wind speeds at sites of monitors.

Daily vector averaged wind speeds were calculated from on-site 1-hour vector winds for each of the 40 days of highest observed daily sulfur dioxide concentrations at the rural Dunn Center, TRNP-S and TRNP-N monitoring sites. The 40 highest observed daily sulfur dioxide concentrations for these sites are listed in Appendix G of the protocol. Scatter plots of the 40 daily sulfur dioxide concentrations paired with daily wind speeds for the three monitoring sites are attached as figures 1, 2 and 3. [Note. The TRNP-N monitoring site was established during 2001; only 2002 monitoring data are shown in the attached scatter plot.]

The scatter plots indicate that the daily vector averaged wind speeds for the 40 highest daily sulfur dioxide concentrations are less than 8 meters per second (17.9 miles per hour) for the rural Dunn Center and TRNP-N monitoring sites. The wind speeds at the TRNP-S monitoring site are higher, which apparently is due to the topographic features at and surrounding the site. (See also Appendix A.) Daily vector averaged wind speeds at the three sites are seldom less than 1 meter per second.

The plots illustrate that the larger observed 24-hour sulfur dioxide concentrations at sites of monitors in the South and North Units of TRNP do not appear to increase as wind speed decreases. Therefore, no regression analyses of the data were completed.

3.2 Explanation of the enhanced RUC-2 meteorological data.

Pursuant to discussions between the department and EPA, the department contracted with WindLogics, Inc., (formerly SSESCO) for a paper that expands the description of the ARPS Data Assimilation System (ADAS) enhanced Rapid Update Cycle (RUC-2) data. The title of this paper is "RUC Analysis-based CALMET Meteorological Data for the State of North Dakota." Additional descriptions are provided on page 7 and in Attachment 2 of the protocol. The protocol refers to the enhanced RUC-2 data as $RUC2^d$ data.

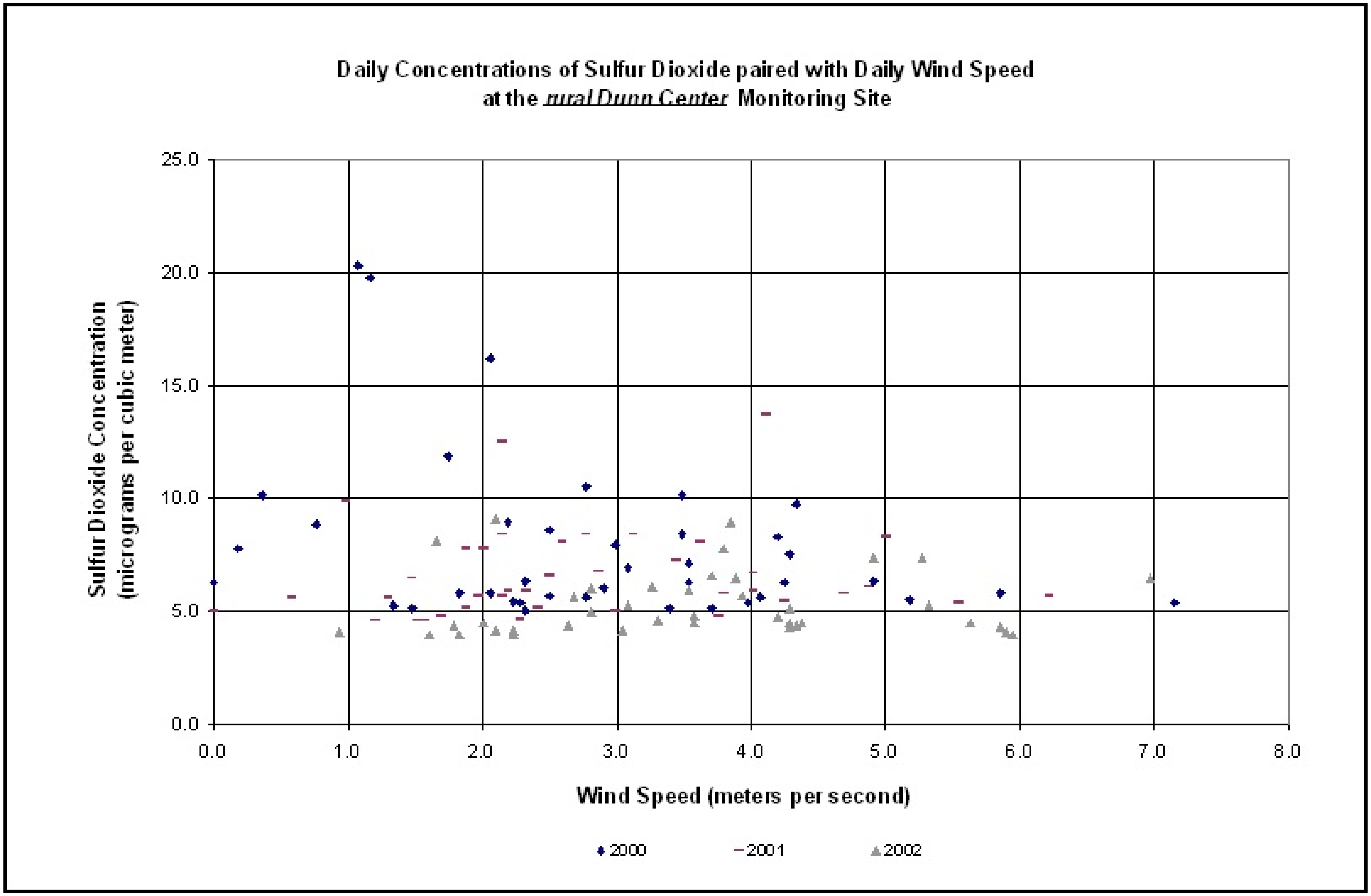
The WindLogics' paper provides detail on its process for using the ADAS assimilation software developed by the University of Oklahoma. This software was used 1) to interpolate the NOAA RUC gridded data onto an MM5 grid and file format suitable as input to the CALMET model and 2) to assimilate NWS surface observations.

3.3 Agreement between enhanced RUC-2 and NWS wind speeds.

During development of the protocol, EPA indicated that the prognostic meteorological model known as MM5 has been shown to produce wind speeds at 10-meters above ground level (AGL) which are biased larger than actual wind speeds when the actual wind speeds are less than 5 meters per second. The corollary question became: Are wind speeds in the three years of ADAS enhanced RUC-2 data biased higher than NWS wind speeds? If so, then predicted concentrations using the enhanced RUC-2 might be biased low.

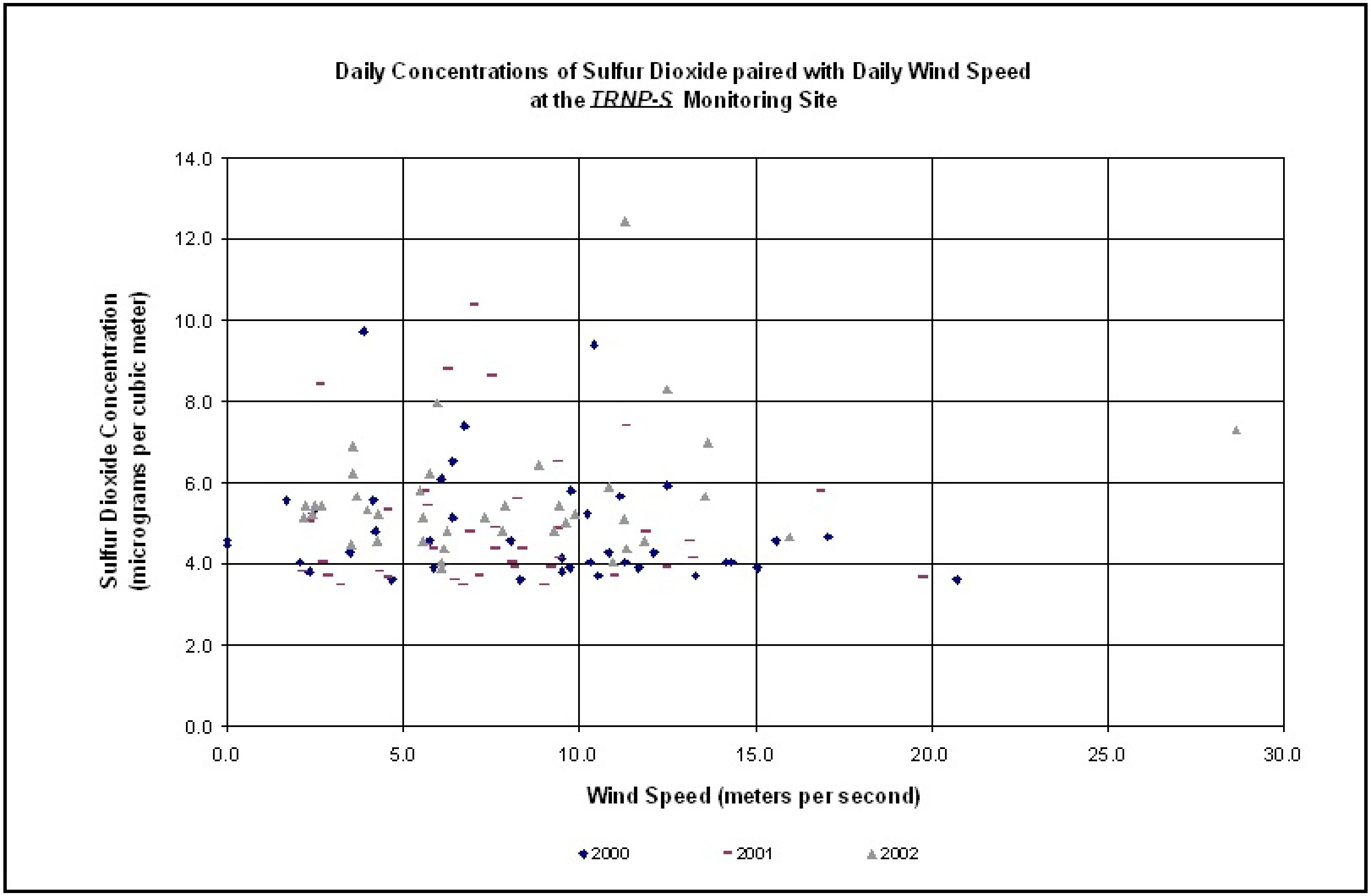
So as to address the question, the department also contracted with WindLogics, Inc., for a paper that provides results of a statistical comparison of the enhanced RUC surface winds with NWS observed surface winds. It completed a statistical assessment of the correspondence between the enhanced RUC-2 ($RUC2^d$) and hourly NWS winds at 10-meters AGL. The title of the paper is "A Comparison of NOAA RUC Analysis Surface Winds and ADAS-Enhanced RUC Analysis Winds with Surface Observations."

Results of the WindLogics, Inc., paper indicate that ADAS re-introduction of NWS surface wind data with RUC-2 40-kilometer grid data and extrapolation to a 10 kilometer grid is more representative of the NWS surface wind data as the enhanced RUC-2 data contain less deviation from the NWS data. The deviation is reduced about 40 percent. The wind speed bias is -0.145 meters per second, which indicates that ADAS enhanced RUC-2 wind speeds are slightly lower than observed wind speeds. Therefore, the enhanced RUC-2 wind speeds are not biased, on average, so as to cause lower predicted concentrations.



Daily Concentrations of Sulfur Dioxide paired with Daily Wind Speed
at the rural Dunn Center Monitoring Site
Sulfur Dioxide Concentration
(micrograms per cubic meter)
25.0
20.0
15.0
10.0
5.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Wind Speed (meters per second)
2000
2001
2002

Figure 1.



Daily Concentrations of Sulfur Dioxide paired with Daily Wind Speed
at the TRNP-S Monitoring Site
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Sulfur Dioxide Concentration
(micrograms per cubic meter)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Wind Speed (meters per second)
2000
2001
2002

Figure 2.

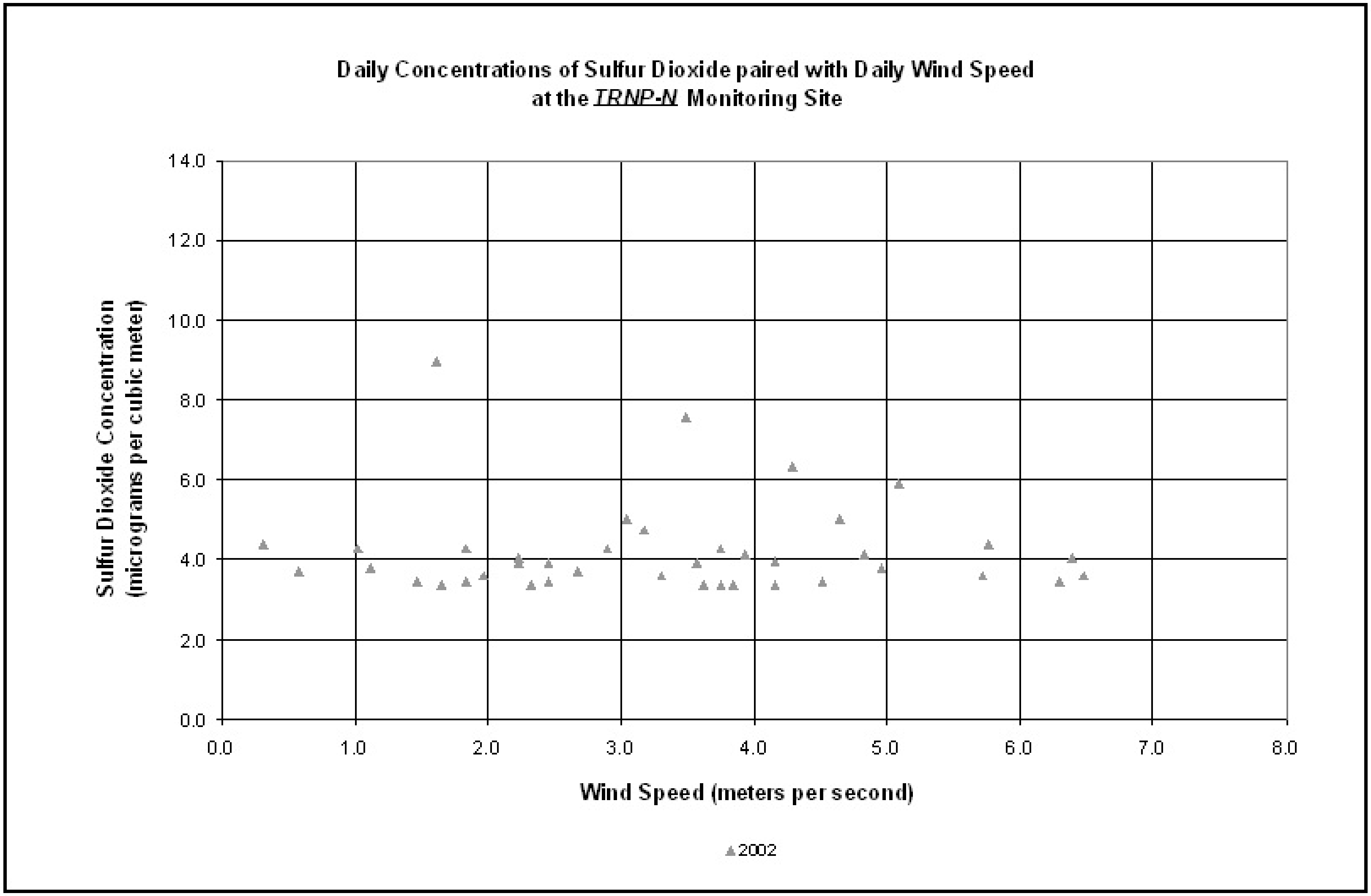

Daily Concentrations of Sulfur Dioxide paired with Daily Wind Speed
at the TRNP-N Monitoring Site
Sulfur Dioxide Concentration
(micrograms per cubic meter)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Wind Speed (meters per second)
2002

Figure 3.

4.0 Role of monitoring data in modeling.

The department has operated and maintained instruments (i.e., monitors) for measuring (i.e., monitoring) ambient sulfur dioxide since 1980. Concentrations of sulfur dioxide are amounts as micrograms (µg or ug) within a cubic meter of air (m^3 or m3). The monitors provide time averaged concentrations of sulfur dioxide – historically for one hour periods, but in recent years for five minute periods. The hourly concentrations are averaged for the 2,920 sequential 3-hour and the 365 sequential 24-hour (daily) time blocks during the year.

The observed (a.k.a. monitored) concentrations at sites of monitors in the South and North Units of TRNP, at rural Dunn Center and at rural Hannover during years 2000, 2001 and 2002 provide ten (10) sets of data for assessing model accuracy; for example, one set of observed concentrations for each year at each site. The sets of data provide an opportunity to examine temporal (year to year) and spatial (site to site) consistency in model accuracy test results when using the inputs provided by the protocol. A map of the sites of the four monitors is provided in Appendix B.

Following the protocol, the CALMET and CALPUFF models have been used to predict the concentration (also $\mu g/m^3$ or ug/m3) of sulfur dioxide for each hour sequentially through the year. The predicted hourly concentrations are also averaged for each sequential 3-hour and 24-hour time block during the year. *(Note. The words "predicted", "model predicted", and "modeled" are used interchangeably in this report.)*

4.1 <u>Example of value of observed concentrations</u>.

Daily observed concentrations of sulfur dioxide and daily predicted concentrations are plotted sequentially through the year as shown in figure 4. Additional figures are provided in Appendix C. Due to the lower detection level of the sulfur dioxide monitor, daily averages less than 1 part per billion (ppb) were set to 1 ppb (2.62 ug/m3). (See Appendix H of the protocol.) Because the source inventories of emitted sulfur dioxide do not represent all sulfur dioxide emitted within, or transported into, the modeling domain, a background concentration of 1.5 ug/m3 was added to predicted concentrations. (See pages 21 through 24 of the protocol.)

All model data inputs as provided by the protocol were used, except the 2000-2001 actual emissions of several sources. A source's actual emissions is its total sulfur dioxide emitted during two consecutive years divided by the total operating hours during those years. The 2000-2001 actual emissions were replaced with hourly CEM sulfur dioxide emissions. (See also Appendix G of the protocol.) In essence, hourly CEM emissions are paired with hourly CALMET processed meteorological data. This modeling approach links concurrent source emissions with concurrent synoptic meteorology for comparing predicted concentrations with time-concurrent observed concentrations as illustrated in figure 4.

Generally, time-series predicted concentrations of sulfur dioxide exhibit significant error when compared to time-series observed concentrations. (For example, see paragraph b, section 10.1.2 of 40 CFR 51, Appendix W.) The error can be the result of imperfect treatment of atmospheric air motion (plume transport), imperfect treatment of boundary layer mixing depth, imperfect treatment of complex physical processes (vertical and horizontal dispersion and plume depletion via deposition, etc.), and inadequate data inputs. For example, some physical processes are handled with domain-scale techniques, and one land-use/land-cover data set is used rather than seasonal land-use/land-cover data sets.

Power plants and other emitters of sulfur dioxide in North Dakota are located 120 to 200 kilometers from the monitors in the South and North Units of TRNP. Trajectories of plumes of emitted sulfur dioxide depend on the temporal and regional dynamics of air in motion. The attached time-series plot, as well as the plots in Appendix C, illustrates frequent agreement in daily timing of larger observed concentrations and larger predicted concentrations.

4.2 Comments.

The frequent agreement in daily timing of predicted sulfur dioxide concentrations and observed concentrations likely is due to the ADAS enhanced RUC-2 meteorological data and the values and settings of some CALMET control-file variables. [Note. The department did not use the NWS data only option provided by the protocol. Results using this option could be used to verify that use of the ADAS enhanced RUC-2 data improves the timing accuracy of predicted concentrations.]

Generally, the models over or under predict observed 24-hour sulfur dioxide concentrations during the year. The reasons might be imperfect mixing heights and vertical dispersion (e.g., puff splitting) over the modeling domain rather than, or in addition to, imperfect plume time-dependent trajectories.

When ambient sulfur dioxide concentrations are larger than the monitor's lower detection level, observed sulfur dioxide hourly concentrations provide reliable measures of actual ambient sulfur dioxide. When 24 consecutive hours of observed hourly concentrations are averaged, some hourly concentrations can be less than the monitoring instrument's lower detection level. If so, a value of one-half the lower detection level is used as the hourly concentration for that hour. (See Appendix H of the protocol.) This practice can result in some uncertainty in 24-hour sulfur dioxide concentrations. Instruments having a lowest achievable detection level of 0.5 ppb or less would reduce the uncertainty of larger 3-hour and 24-hour concentrations.

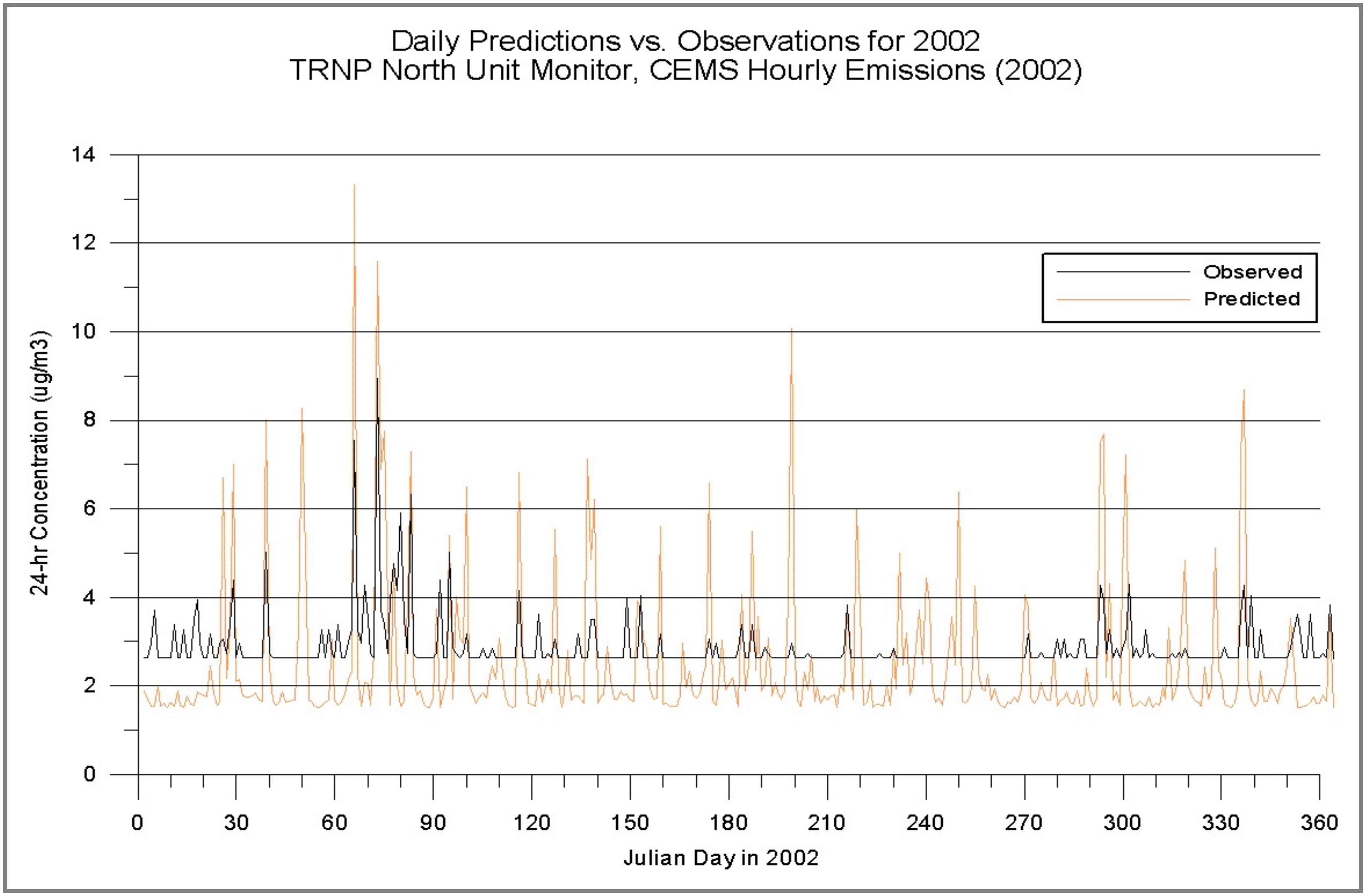

Daily Predictions vs. Observations for 2002
TRNP North Unit Monitor, CEMS Hourly Emissions (2002)
Observed
Predicted
24-hr Concentration (ug/m3)
0
2
4
6
8
10
12
14
0
30
60
90
120
150
180
210
240
270
300
330
360
Julian Day in 2002

Figure 4.

5.0 Model accuracy tests.

5.1 Spatial variation of predicted concentrations.

The department operates and maintains instrumentation for measuring ambient sulfur dioxide at several locations throughout North Dakota. The observed and predicted sulfur dioxide concentrations at the sites of monitors in two TRNP Class I areas and at other receptors in these areas can be used to illustrate probable correspondence between actual and predicted concentrations throughout these areas. The model predicts the concentrations from hour to hour throughout the year. These observed and predicted hourly concentrations are averaged for each sequential 3-hour and 24-hour block during the year.

In historical data analysis, the highest of the 2,920 observed or predicted 3-hour concentrations and the highest of the 365 24-hour concentrations are often excluded as data outliers due to unusual weather circumstances.

A map of plotted second highest 24-hour predicted concentrations during 2000 for receptors in the South Unit of TRNP is shown in figure 5. *(The plotted predicted concentrations do not include a background concentration.)* Maps for the 24-hour period during years 2001 and 2002 for the 3-hour period are provided in Appendix D. The second highest predicted concentrations at the sites of monitors are also shown. The protocol's 2000-2001 actual emissions were used with each of the three years of meteorological data.

These maps illustrate the range (smallest and largest) and spatial variation of these predicted concentrations. For example, the map in figure 5

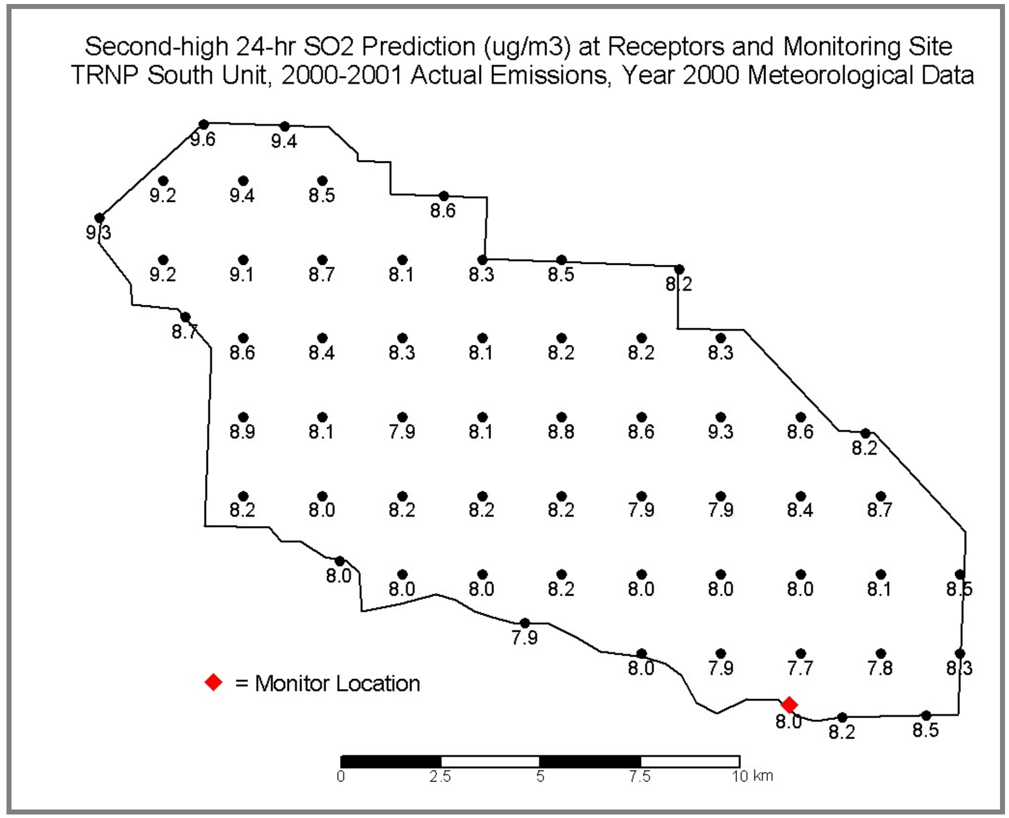


Figure 5.

Table 3a. Predicted second highest sulfur dioxide concentrations (ug/m3) when using 2000-2001 actual emissions. *						
Meteorological data	Year 2000		Year 2001		Year 2002	
	24-hour	3-hour	24-hour	3-hour	24-hour	3-hour
TRNP–S;						
at monitoring site	8.0	34.8	7.4	24.9	17.4	45.3
lowest among receptors	7.7	33.2	5.3	13.8	12.7	30.5
highest among receptors	9.6	38.6	7.7	27.4	17.6	45.5
TRNP–N;						
at monitoring site	9.9	27.2	8.4	28.4	11.6	36.0
lowest among receptors	8.0	21.0	7.8	21.6	11.4	35.1
highest among receptors	11.1	27.4	11.8	29.4	16.2	43.4
* The numbers do not include a background concentration (1.5 ug/m3).						
Table 3b. Observed second highest sulfur dioxide concentrations (ug/m3).						
TRNP–S	9.39	22.71	8.81	30.57	8.30	25.33
TRNP–N	**	**	**	**	7.53	23.58
** The site of the monitor was established during year 2001.						

reveals the highest of the predicted second highest 24-hour concentrations at each receptor, when using 2000 weather data, occurs in the northwest region of the Class I area. [Maps in Appendix D reveal that the highest of predicted second highest concentrations, when using 2001 and 2002 weather data, occur near the site of the monitor.]

A tabulation of concentration data from the maps is provided in table 3. The table illustrates the variability among predicted short-term concentrations. All model input followed the protocol.

The second highest predicted 24-hour concentrations for South-Unit receptors for 2002 are generally twice as large as the second highest predicted 24-hour concentrations for years 2000 and 2001. A similar pattern occurs among years for predicted 3-hour concentrations.

Table 3 also provides the second highest observed concentrations obtained from the two monitors in the South and North Units of TRNP. (See Appendix H of the protocol.) When the background concentration of 1.5 ug/m3 is added to predicted concentrations, the second highest observed 24-hour concentration is within the range of second highest predicted 24-hour concentrations among receptors for years 2000 and 2001. However, the second highest predicted 24-hour concentrations among receptors for 2002 are much larger than the second highest observed 24-hour concentrations for that year; for example, 18.9 ug/m3 (17.4 plus 1.5) versus 8.3 ug/m3. Similarly, the second highest predicted 3-hour concentrations for receptors for 2002 are larger than the second highest observed 3-hour concentrations for that year; for example, 46.8 ug/m3 (45.3 plus 1.5) versus 25.33 ug/m3.

5.2 Predicted concentrations paired with observed concentrations.

Accuracy tests assess correspondence between predicted concentrations and observed (actual ambient) concentrations. Pages 21 through 24 in the protocol describe the background sulfur dioxide concentration for the tests.

Graphs of the 25 largest predicted short-term concentrations at sites of monitors paired with the 25 largest actual ambient concentrations at those sites illustrate agreement between the predicted and observed concentrations; for example, figure 6. The highest predicted concentration is paired with the highest observed concentration, the second highest predicted concentration with the second highest observed concentration, and so forth.

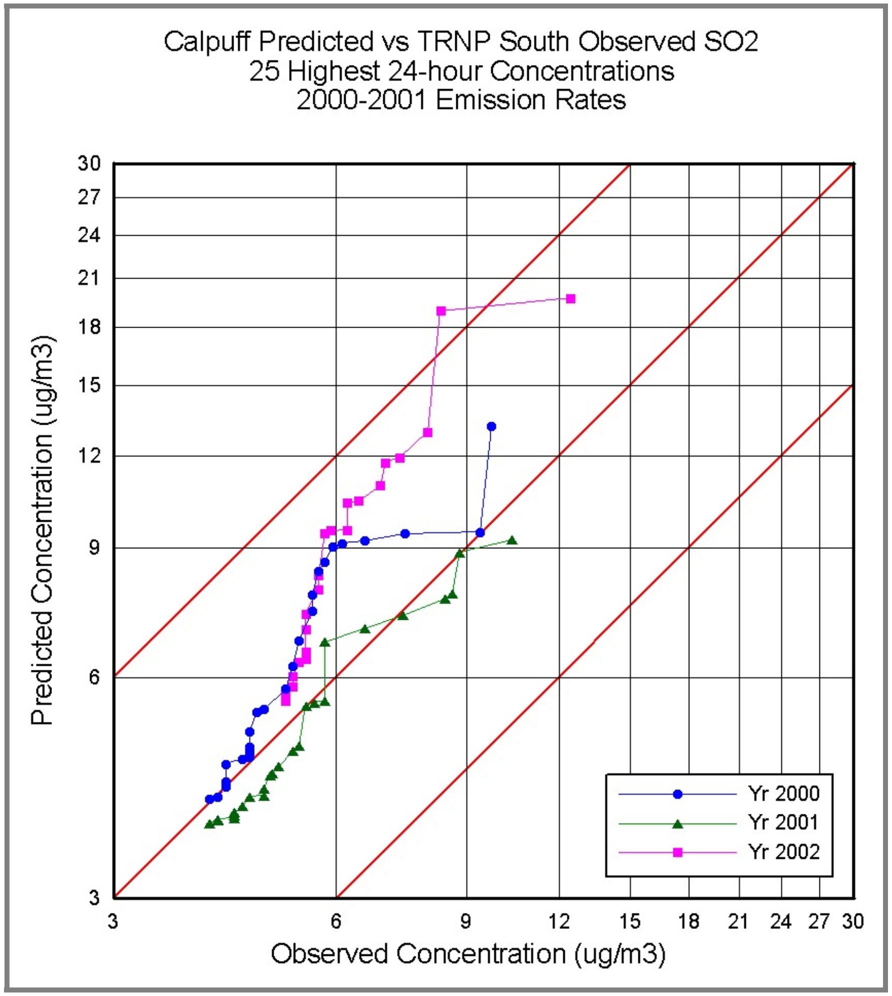


Figure 6.

Figure 6 shows the largest 25 24-hour predicted concentrations paired with the largest 25 24-hour observed concentrations at the site of the monitor located in the South Unit of the TRNP. Other graphs for the 24-hour period at other sites and for the 3-hour period are provided in Appendix E. *(Plotted predicted concentrations shown in these graphs include a background concentration of 1.5 ug/m3.)*

The graphs illustrate significant differences between paired predicted and observed short-term concentrations. The differences are due to day-to-day and year-to-year variations in the enhanced RUC-2 meteorological data and other weather data, because all other protocol inputs are the same for each year.

Figure 6 illustrates that over prediction bias for 2002 increases as observed concentrations increase. The amount of over prediction for larger predicted concentrations exceeds 5 ug/m3, which is the PSD 24-hour sulfur dioxide increment. (See also section 10.1 of this report .) The predicted second highest 24-hour concentration at the site of the monitor during 2002 is more than twice the second highest observed concentration at that site. This predicted concentration occurred on Julian day 250. (Days on the Julian calendar are numbered from 1 for January 1, 32 for February 1, etc., through December 31.)

Sulfur dioxide is transported westward by easterly winds as illustrated in Appendix A. Graphs in Appendix E illustrate that model over prediction bias at the rural Dunn Center monitoring site is larger for 2002 than for years 2000 and 2001. Apparently, the higher over prediction bias in 2002 predicted concentrations at the South and North Units of the TRNP occurs upwind (e.g., Dunn Center) before plumes of emitted sulfur dioxide arrive at these Units.

Table 4. Averaged accuracy ratios when using 2000-2001 actual emissions. *

Meteorology	Year 2000	Year 2001	Year 2002
24-hour:			
TRNP–S	1.20	0.94	1.41
TRNP–N	**	**	1.79
Dunn Center	1.11	1.22	1.75
Hannover	1.40	1.79	1.24
3-hour:			
TRNP–S	1.50	1.10	1.79
TRNP–N	**	**	1.84
Dunn Center	1.33	1.35	2.06
Hannover	1.37	1.69	1.41

* Ratios include a background concentration of 1.5 ug/m3.
** The site of the monitor was established during 2001.

The amount of over or under prediction is the ratio resulting from division of the predicted concentration by the paired observed concentration. Pursuant to the protocol, the accuracy of predicted concentrations is calculated as the average of the 25 ratios of paired predicted and observed concentrations. The averaged accuracy ratios are provided in table 4.

Averaged accuracy ratios for 24-hour predicted concentration for years 2000 and 2001 are 1.22 and smaller, which is acceptable (section 10.1 of this report). Averaged ratios for 2002 are exceptionally high, and the ratio of 2.06 for the rural Dunn Center site exceeds the factor of two criterion often cited by EPA.

5.3 Comments.

In each of years 2000, 2001 and 2002, some of the largest observed 24-hour concentrations used in accuracy tests occur on back to back Julian days. (See tables of data in Appendix B of this report.) Back to back days of larger concentrations suggest persistent synoptic meteorology; so, these back to back concentrations did not occur during independent weather events. Similarly, some of the largest predicted 24-hour concentrations likely occur on back to back days.

6.0 Trends in 2000 – 2002 emissions.

As previously shown, averaged accuracy ratios for 2002 were larger than accuracy ratios for years 2000 and 2001. One ratio exceeded the factor of two criterion often cited by EPA. Other ratios for 2002 are in the range of 1.8. Excessive over prediction by models, as illustrated in Appendix B of the protocol and section 10.1 of this report, has significant implication for air quality science, public policy and air quality management.

6.1 Emission trends after 2001.

The protocol follows rule, interpretive rule or EPA guidance when the same sulfur dioxide emission rates are used for each of the three years of the ADAS enhanced RUC-2 input meteorology and other weather data. Specifically, actual emissions are total annual emissions during two consecutive years divided by the total operating hours during those years. The actual emission rates (page 20 of the protocol) represent rates preceding a permit application or current time line rates. If changes in emission rates occur during the three years of input meteorology, then rates used in the modeling protocol may not reflect a yearly correspondence between emissions and monitoring data, which are linked by meteorology.

More than four years have elapsed since the State initially compiled sulfur dioxide emissions data. Sulfur dioxide emissions data from source emissions inventory reports and from EPA's Acid Rain Program data files are now available for years 2002 and 2003. The sulfur dioxide emission rate data for sources, exclusive of oil and gas flares and treaters, for the four years from 2000 through 2003 are provided in table 7.

Table 7 demonstrates that total 2002 sulfur dioxide emission rates are less than total 2000-2001 actual emissions. In 2002, there were small increases in the emissions for some sources and significant decreases for other sources. When source emissions change, sulfur dioxide concentrations at sites of monitors also change. So, comparison of predicted sulfur dioxide concentrations based upon 2000-2001 emissions data with observed sulfur dioxide concentrations from 2002 is inappropriate.

6.2 Impact of emission trends.

The 2002 emission rates (table 7) were used – in lieu of the protocol's 2000-2001 rates – with 2002 input meteorology for modeling predicted 2002 concentrations so as to illustrate appropriate pairing of predicted and observed concentrations. All other model input data remained unchanged. A graph of paired 24-hour predicted and observed concentrations for the site of the monitor located in the

South Unit of the TRNP is shown in figure 7. *(Plotted predicted concentrations include a background concentration of 1.5 ug/m3.)* Graphs for the 24-hour period at other sites and for the 3-hour period are provided in Appendix E.

Figure 7 illustrates an improved agreement between predicted and observed 24-hour averaged concentrations when using 2002 emissions. The averaged accuracy ratios for 2002 using this approach were computed and are shown in table 5.

All averaged accuracy ratios for 2002 decrease when using 2002 emission rates, and most of them by about 0.2. These decreases indicate that use of the 2002 emission rates rather than the protocol's 2000-2001 actual emissions provides better agreement between predicted and observed short-term sulfur dioxide concentrations.

Table 5. Year 2002 averaged accuracy ratios. *

	USING protocol emission rates	USING 2002 emission rates
24-hour:		
TRNP–S	1.41	1.26
TRNP–N	1.79	1.60
Dunn Center	1.75	1.54
Hannover	1.24	1.08
3-hour:		
TRNP–S	1.79	1.56
TRNP–N	1.84	1.62
Dunn Center	2.06	1.82
Hannover	1.41	1.23

* Ratios include a background concentration of 1.5 ug/m3 for predicted concentrations.

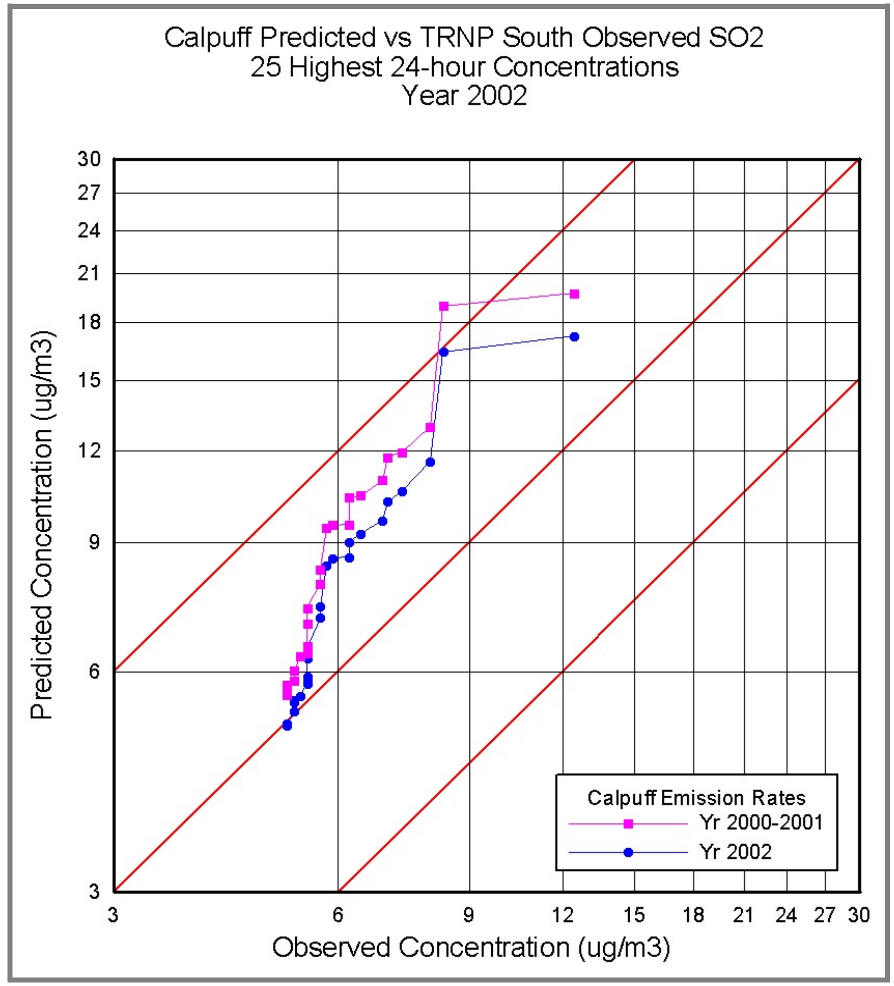


Figure 7.

6.3 Consistency between actual emissions and hourly CEM data.

Concurrent hourly CEM sulfur dioxide emissions of the state's coal-fired electric utilities are shown for years 2000 and 2001 in Appendix G of the protocol. These hourly emissions are larger than actual emissions, as defined, about one of every four hours during those years. Therefore, an issue has been whether the protocol results would understate short-term sulfur dioxide concentrations.

When available, hourly CEM sulfur dioxide emissions were used rather than 2000-2001 actual emissions to assess the effect of the hourly CEM emissions on accuracy performance. All other model inputs remained unchanged. This procedure optimizes use of emissions data and transport meteorological data; specifically, hourly CEM sulfur dioxide emissions are temporally consistent with the meteorological data. [Notes. 1) CEM systems were first installed about 1995; so, hourly CEM sulfur dioxide emissions data are not available for use as PSD baseline emissions. 2) All previous accuracy tests that were reported by the department used the hourly CEM sulfur dioxide emissions of sources when available; i.e., such data are not collected at, or required to be reported by, some sources.]

Averaged accuracy ratios resulting from use of the hourly CEM emissions are provided in table 6. Within the table, notation "00-01" refers to the 2000-2001 actual emissions of the protocol and "02" refers to the 2002 emissions per previous discussion in this report. The accuracy test results indicate that use of the hourly CEM emissions as a substitute for 2000-2001 actual emissions does not appreciably improve averaged accuracy ratios for meteorological years 2000 and 2001. In fact, many ratios increased slightly.

6.4 Comments.

Historically, modeling methods have used as many as five years of meteorological data and the same emission rates, or changes in rates, were used for each year of the meteorological data. However in this instance, total emissions declined during 2002, which is the third of the three consecutive years of the protocol's ADAS enhanced RUC-2 meteorological data.

The assessment of model accuracy performance as provided by the protocol revealed over-prediction biases within predicted 24-hour sulfur dioxide concentrations that are larger than 40 percent. The degree of 24-hour, and 3-hour, over-prediction when using 2002 weather data was reduced about 20 percent when 2002 emissions were substituted for the protocol's 2000-2001 actual emissions.

The accuracy of predicted concentrations was re-assessed by substituting hourly CEM emissions year by year for the protocol's actual emissions. The results confirm that actual emissions are an adequate representation of source emission rates. The results also confirm that use of the protocol's 2000-2001 actual emissions with 2002 transport meteorological data caused an unacceptable over prediction bias in predicted concentrations.

Table 6. Averaged accuracy ratios for each of three sulfur dioxide emission rates. *							
Meteorology	Year 2000		Year 2001		Year 2002		
Emissions	00-01	CEM	00-01	CEM	00-01	CEM	02
24-hour:							
TRNP–S	1.20	1.26	0.94	1.01	1.41	1.31	1.26
TRNP–N	**	**	**	**	1.79	1.62	1.60
Dunn Center	1.11	1.10	1.22	1.15	1.75	1.56	1.54
Hannover	1.40	1.24	1.79	1.77	1.24	1.10	1.08
3-hour:							
TRNP–S	1.50	1.44	1.10	1.12	1.79	1.57	1.56
TRNP–N	**	**	**	**	1.84	1.62	1.62
Dunn Center	1.33	1.33	1.35	1.26	2.06	1.83	1.82
Hannover	1.37	1.19	1.69	1.83	1.41	1.35	1.23

* Ratios include a background concentration of 1.5 ug/m3. ** The site of the monitor was established during 2001.

In addition, the amounts of over prediction for 24-hour concentrations – when accuracy ratios are larger than 1.4 – can exceed 5 ug/m3, which is the PSD Class I 24-hour sulfur dioxide increment. (See section 10.1 of this report.) This bias is contained in data in tables and graphs provided in this report that describe or are based upon predicted 2002 concentrations.

The averaged accuracy ratios for the 3-hour predicted concentrations at the TRNP–S and rural Dunn Center monitoring sites were larger than ratios for the 24-hour concentrations. The results of all accuracy tests included averaged accuracy ratios near 1.0. Therefore, comprehensive sensitivity tests were not conducted, and no protocol values or settings for CALMET and CALPUFF control file input variables were changed.

Model accuracy performance is less of an issue when modeling methods result in no exceedance of a PSD increment. But, model accuracy performance becomes an issue when modeling methods result in exceedances of an increment. While modest model over prediction is preferred, the factor of two (ratio of 2) often cited by EPA is not a bright line. (See 40 CRF Part 51, Appendix W, section 10.) There are no guiding principles for acceptable or unacceptable model accuracy performance.

Table 7. Sulfur dioxide emission rates (lb/op-hr) of sources for years 2000, 2001, 2002 and 2003; and actual emissions (lb/op-hr) of the sources for 2000–2001 and 2002–2003.

			MOU protocol						
Source	**Unit**	**Basis**	**2000**	**2001**	**00-01 #**	**2002**	**2003**	**02-03 #**	**fn**
R.M. Heskett Station	1	e.i.r., CEM	246.8	249.2	248	220.1	256.4	241.8	
	2	e.i.r., CEM	584.6	634.4	612.7	536.3	669.7	602	
Leland Olds Station	1	e.i.r., CEM	4,088.20	4,292.10	4,179.20	3,948.60	4,457.50	3,833.00	fn 3
	2	e.i.r., CEM	8,293.30	8,808.10	8,145.10	7,721.70	7,866.60	7,379.70	fn 3
M.R. Young Station	1	e.i.r., CEM	4,806.70	5,479.00	5,161.40	4,782.80	4,831.70	4,805.90	
	2	e.i.r., CEM	5,033.00	3,521.70	4,353.20	2,131.20	2,450.50	2,291.20	
Stanton Station	1 & 10	e.i.r., CEM	2,314.50	2,416.70	2,389.80	2,254.60	2,566.10	2,443.50	
Tioga Gas Plant	SRU Incinerator	CEM	295.9	305.2	300.6	350.2	296.2	322.6	
Lignite Gas Plant	SRU Incinerator	CEM	105.6	ditto	105.6	0	0	0	fn 1
Mandan Refinery	Boilers + Crude Furnace	e.i.r.	227.9	37.1	133	52.1	81.2	66.1	
	FCCU	e.i.r.	970.5	1,084.50	1,026.90	913.9	1,033.90	971	
	Alkylation Unit	e.i.r.	7.3	8.1	7.7	10.1	8.6	9.4	
	Ultraformer Furnaces	e.i.r.	15.1	17.2	15.9	13.1	14.2	13.6	
	SRU Incinerator	e.i.r.	42.1	48.4	45.3	58.6	60.2	59.4	
Coal Creek Station	1	CEM	3,319.10	3,423.40	3,368.10	3,034.00	3,223.00	3,132.70	
	2	CEM	3,041.20	2,910.60	2,972.80	2,888.00	3,142.80	3,015.00	
Antelope Valley Station	1	CEM	1,597.50	1,585.50	1,590.80	1,744.90	1,770.30	1,758.20	
	2	CEM	1,503.80	1,488.70	1,496.00	1,709.10	1,786.90	1,748.10	
Coyote Station	1	CEM	3,906.60	4,025.50	3,955.40	3,475.50	3,643.10	3,553.70	
Grasslands Gas Plant	SRU Incinerator	CEM	113.4	ditto	113.4	0	0	0	fn 2
Little Knife Gas Plant	SRU Incinerator	CEM	82.1	77.9	80.1	63	70.7	66.8	
Great Plains Synfuels	Main stack	CEM	1,247.00	941.8	1,094.40	826.1	751.6	788.6	
	Start-up flare	allowable	119	119	119	21.8	11	16.2	
	Main flare	e.i.r.	177.3	190.6	184	96.5	236.3	166.4	
	Back-up flare	allowable	78	78	78	26.6	109.7	34.8	
PPL Corp Colstrip	3	CEM			742.9	769.4	776.2	773.4	
	4	CEM			719	744.3	759	751	
CELP Colstrip		CEM			419.8	302.9	302.9	302.9	
		Total =			43,658.20	38,695.40	41,176.30	39,147.00	

lb/op-hr = pounds per operating hour
e.i.r. = annual emissions inventory reports
# = actual emissions
fn1 = began injecting sour gas during August 2002
fn2 = began injecting sour gas during March 2002
fn3 = see Appendix E of the MOU protocol

7.0 Calculating Deterioration.

The protocol provides EPA's current method and an Alternate method for calculating deterioration of ambient short-term sulfur dioxide concentrations. The difference between the methods lies in the application of the baseline concentration. (See pages 25, 26 and 27 in the protocol.) For example, EPA's current method does not determine the baseline concentration.

EPA's current method evaluates changes in predicted concentrations for each of the 2,920 3-hour and 365 24-hour periods throughout the year. Its method is often referred to as the paired in space (S) and time (T) method. There are no meteorological data during the later 1970s for modeling PSD baseline emissions, so the same meteorological data are used year by year to model PSD baseline emissions and current emissions. Therefore, its method is inappropriate because the method forces meteorological coupling, or synchronization, of calculated changes in predicted concentrations. (See also footnote 16 on page 63 of the protocol.)

The Alternate method of calculating short-term deterioration is consistent with law and rule definitions for baseline concentration. The method establishes the baseline concentration as the second highest short-term concentration throughout the year at each receptor by modeling the PSD baseline emissions inventory. (See page 26 of the protocol.) This method is often referred to as the paired-in-space-only (S) method. In this approach, the baseline concentration for each receptor represents the worst-case short-term concentration due to the PSD baseline emissions. The paired in space method does not couple calculated deterioration to daily meteorology, because models have not excelled in predicting concentrations paired in space and time with actual observations.

7.1 <u>Reference concentrations using EPA's current method</u>.

Daily averages of predicted hourly concentrations for 2002 are shown on attached figure 10 for 1) PSD baseline emissions and 2) current (2000-2001 actual) emissions. *(The predicted concentrations in figure 10 do not include the background concentration.)* The data presentation assumes that background sulfur dioxide was consistent throughout both baseline and current time lines. Because the 24-hour averages for the two time lines are meteorologically coupled, daily predicted concentrations are shown to either decrease or increase; decreases are improved air quality, and increases are deteriorated air quality.

The figure depicts approximately fifteen meteorological episodes during 2002 when predicted daily concentrations, due to current emissions, are larger than 4 ug/m3; during six episodes, the daily predicted concentrations due to current emissions are larger than 8 ug/m3. In addition, the figure depicts three episodes when the daily predicted concentrations due to PSD baseline emissions are larger than 8 ug/m3. [Note. The third highest daily observed concentration during 2002 at the site of the monitor in the South Unit of TRNP was 7.97 ug/m3. (See page 67 in the protocol. See also the graph in figure 6 of this report.)]

Figure 10 illustrates the day to day variation in 24-hour averages of predicted hourly concentrations (which do not include a background concentration) due to PSD baseline emissions; these daily concentrations range from 0.0 upward to 11.6 ug/m3. EPA's current method for calculating deterioration relies on each predicted daily concentration due to PSD baseline emissions as a reference for calculating daily changes in concentrations.

7.2 <u>Baseline concentration as a single value for the year</u>.

The second highest of the 365 daily averages of predicted sulfur dioxide concentrations at receptors in the South Unit of the TRNP are plotted on the map in figure 8. *(The plotted model predicted concentrations do not include a background concentration.)* The sulfur dioxide emissions were the PSD baseline emissions as provided by the protocol.

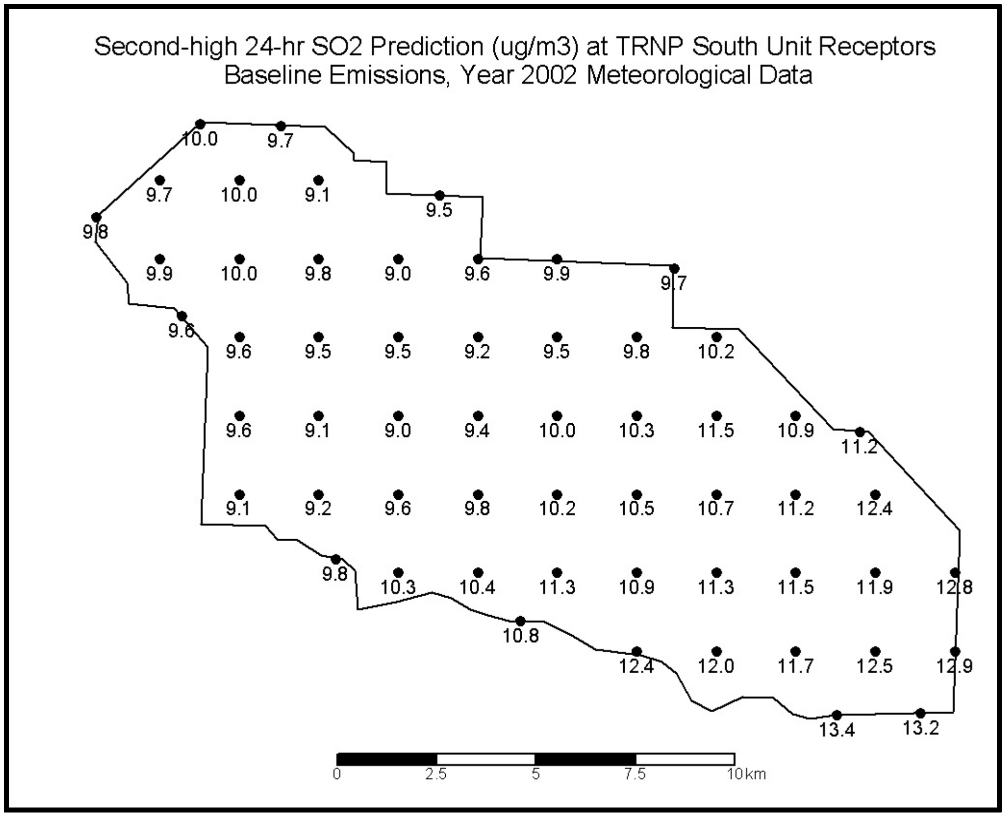


Figure 8.

The map illustrates the PSD 24-hour baseline concentration for each receptor within the Class I area when using 2002 meteorology. For example, the second highest predicted concentration using PSD baseline emissions and 2002 meteorology at receptor number 3 is 9.1 ug/m3. (See also figure 10.) Receptor number 3 is located in the southwest corner of the South Unit. (See page 28 of the protocol.)

The highest predicted 24-hour baseline concentration (1977) for a receptor, when using 2002 meteorology, is 13.4 ug/m3. The lowest predicted 24-hour baseline concentration for a receptor is 9.0 ug/m3.

Predicted 24-hour baseline concentrations for receptors in the vicinity of the monitoring site, which is located in the southeast corner of the South Unit, range from 11.7 ug/m3 to 13.4 ug/m3.

The second highest observed 24-hour concentration during 2002 was 8.3 ug/m3. All predicted baseline concentrations (1977) for individual receptors within the South Unit exceed 8.3 ug/m3, *regardless of whether a background concentration is added to predicted concentrations.*

The second highest of the 2,920 3-hour averages of predicted concentrations at receptors in the South Unit of the TRNP are shown on the map in figure 9. *(The predicted concentrations in the figure do not include a background concentration.)* The sulfur dioxide emissions were the PSD baseline emissions as provided by the protocol. The map illustrates the PSD 3-hour baseline concentration for each receptor when using 2002 meteorology.

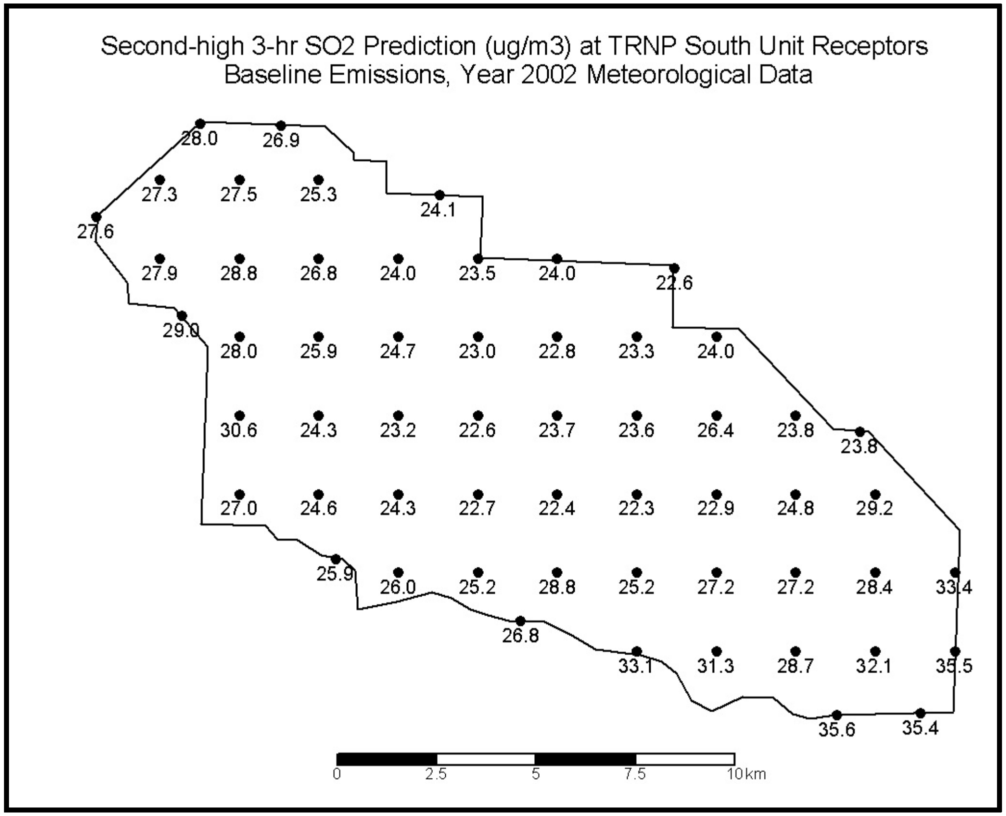


Figure 9.

The highest predicted 3-hour baseline concentration (1977) for a receptor, when using 2002 meteorology, is 35.6 ug/m3. The lowest predicted 3-hour baseline concentration for a receptor is 22.6 ug/m3.

Predicted 3-hour baseline concentrations for receptors in the vicinity of the monitoring site, which is located in the south east corner of the South Unit, range from 28.7 ug/m3 to 35.6 ug/m3.

The second highest observed 3-hour concentration during 2002 was 25.3 ug/m3. Most predicted baseline concentrations (1977) for individual receptors within the South Unit were larger than 25.3 ug/m3 *when a background concentration of 1.5 ug/m3 is added to predicted concentrations.*

7.3 Comments.

The second highest 24-hour sulfur dioxide concentration at a receptor due to PSD baseline emissions is only one of the daily concentrations throughout the year. Figure 10 illustrates that the choice of the reference point for calculation of the deterioration of 24-hour sulfur dioxide concentrations has a profound effect on calculation results. Thus, the proper application of baseline concentration (as adopted by EPA in 1974 and as defined in the CAA and rule) is critical for modeling and calculating deterioration.

The magnitudes of predicted and observed sulfur dioxide concentrations at sites of monitors depend on the temporal sequence and spatial variation of meteorological conditions preceding and during concentration averaging periods as well as the locations and sulfur dioxide emissions of sources. (Maps of sulfur dioxide sources are at pages 18, 54 and 55 in the protocol. Emissions data are at pages 19, 20 and 53 in the protocol and on page 28 of this report.) Amounts of sulfur dioxide emitted by tall stack sources increased from the PSD baseline emissions of about 29,683.9 pound per hour to current 2000-2001 actual emissions of 43,658.2 pounds per hour. Amounts emitted by oil and gas production sources (flares and treaters) located within 50 kilometers of state Class I areas decreased from PSD baseline emissions of about 17,584.0 pounds per hour to year-2000 emissions of 1,487.4 pounds per hour.

Worst case computed deterioration using the Alternate method can exceed deterioration using EPA's current method. Apparently, unique circumstances must occur; for example, the highest and second highest predicted concentrations due to PSD baseline emissions occur respectively on the same two days as the highest and second highest predicted concentration using current emissions. An example is illustrated with figure 10.

Predicted 24-hour sulfur dioxide baseline concentrations at all receptors – when using meteorological data for 2002 and PSD baseline emissions (figure 9) – are larger than second highest observed 24-hour concentration during 2002 at the site on the monitor in the South Unit of TRNP, which was 8.3 ug/m3.

Similarly, Appendix F provides the predicted 24-hour sulfur dioxide baseline concentration for each receptor in the South Unit of TRNP when using meteorological data for years 2000 and 2001 and PSD baseline emissions. (See also pages 63 and 64 of the protocol.) The background adjusted sulfur dioxide baseline concentration for the receptor nearest the site of the monitor was 9.2 and 7.3 ug/m3, respectively, for years 2000 and 2001. The second highest observed sulfur dioxide concentration at the monitoring site for 2000 was 9.39 ug/m3, and for 2001 it was 8.81 ug/m3. (See Appendix H of the protocol.)

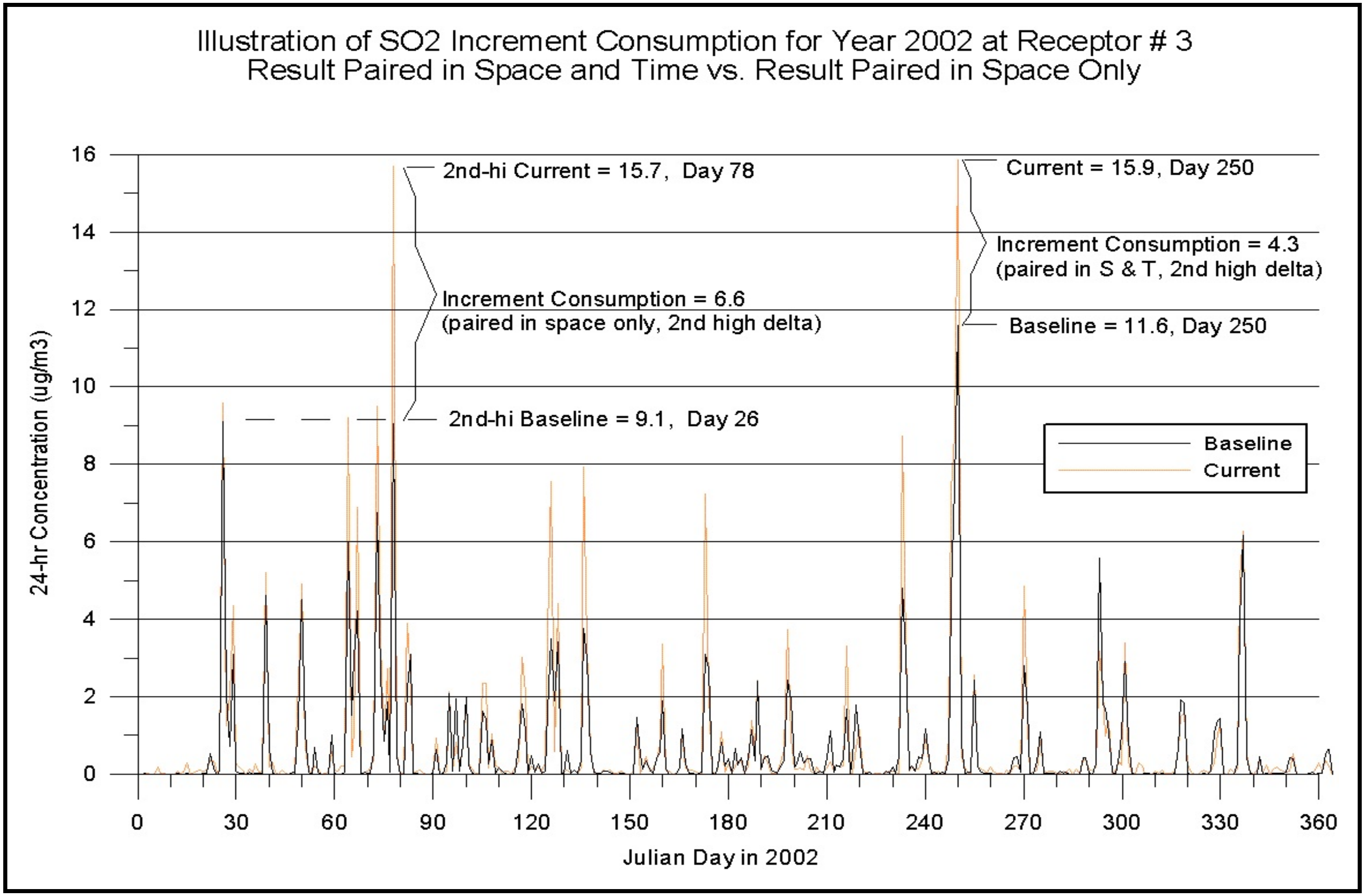


Illustration of SO2 Increment Consumption for Year 2002 at Receptor # 3
Result Paired in Space and Time vs. Result Paired in Space Only
2nd-hi Current = 15.7, Day 78
Increment Consumption = 6.6
(paired in space only, 2nd high delta)
2nd-hi Baseline = 9.1, Day 26
Current = 15.9, Day 250
Increment Consumption = 4.3
(paired in S & T, 2nd high delta)
Baseline = 11.6, Day 250
Baseline
Current
24-hr Concentration (ug/m3)
Julian Day in 2002
0
2
4
6
8
10
12
14
16
0
30
60
90
120
150
180
210
240
270
300
330
360

Figure 10.

8.0 Protocol results.

The federal CAA, EPA rules and State rules allow one exceedance per year of the 24-hour and 3-hour PSD Class I sulfur dioxide increments, with exceptions provided. (For example, see NDAC 33-15-15-01(4.j).) An exceedance occurs when predicted deterioration is larger than the applicable increment. EPA's current method and the Alternate method of calculating increment exceedances are explained on pages 25 - 28 of the protocol and on pages 29 - 33 of this report. In either method, non-attainment of an increment is triggered by a second exceedance at any one receptor among all protocol receptors throughout all Class I areas for all years of input meteorology.

Deterioration which is less than a Class I increment provides a margin for additional sulfur dioxide emissions without exceeding the increment. The effects on ambient concentrations by sources that have been given FLM Certifications of No Adverse Impact (CONAI) can increase these margins, because these effects count toward consumption of the alternate increment per NDAC 33-15-15-01(4.j).

8.1 Results by Class I area.

> Pursuant to the MOU, the protocol contains two options for calculating changes in predicted sulfur dioxide concentrations after PSD baseline. Each option is used for calculating deterioration with and without contributions of sources granted an FLM CONAI.

Results from execution of the protocol (page 27) are provided in Appendix H. A tabular summary of the results is provided below for each of the PSD Class I areas. The only year-to-year difference in protocol inputs is the transport and dispersion meteorology. These summaries provide the highest of the predicted second highest 24-hour and 3-hour changes in concentrations among all model receptors within the Class I area. No exceedances of the 24-hour PSD Class I sulfur dioxide increment occur when using 2000-2001 actual emissions and 2000 and 2001 meteorological data, but the 24-hour increment was exceeded in the South and North Units of the TRNP when using 2002 meteorological data.

The entire protocol was re-executed for 2002, because of improved accuracy ratios when using 2002 emissions. All data inputs, except current sulfur dioxide emission rates, remained unchanged. The 2002-2003 actual emissions of sources, except oil and gas production sources (flares and treaters as described on pages 48 - 54 of the protocol), were used. These results (in the same format) are provided in Appendix I and in the tables below. No second highest deterioration in short-term sulfur dioxide concentrations among receptors in all PSD Class I areas – when using 2002-2003 actual emissions and 2002 meteorological data – exceeded PSD Class I short-term sulfur dioxide increments.

<u>TRNP–South Unit</u>. Modeling results indicate:

1. No deterioration exceeding the increments when replacing 2000-2001 actual emissions with 2002-2003 actual emissions and when using 2002 weather data. Attainment of the PSD short-term sulfur dioxide increment provides margins for additional emissions of sulfur dioxide. A margin is the difference between highest second highest deterioration and the PSD increment.

2. Increases in margins when excluding two sources granted FLM CONAI.

3. Three-hour deterioration pursuant to EPA's method is greater than deterioration pursuant to the paired-in-space-only method (also referred to as the Alternate method). Twenty four-hour deterioration pursuant to EPA's method is sometimes less than deterioration pursuant to the paired-in-space-only method. (See pages 32 and 33 of this report.)

Table 8. Highest second highest deterioration in sulfur dioxide concentrations (ug/m3) for the TRNP–South Unit.

METHOD of tracking changes in concentrations at a receptor due to changes in emissions after PSD baseline	WITH sources granted FLM CONAI and a PSD increment variance			WITHOUT sources granted FLM CONAI and a PSD increment variance		
Meteorological data	2000	2001	2002 *	2000	2001	2002 *
24-hour (PSD increment is 5 ug/m3):						
EPA's paired in space and time	4.4	4.0	5.6 \ 4.7	3.7	3.4	4.6 \ 4.0
Paired in space only	2.8	1.8	6.6 # \ 4.9 #	2.3	1.5	5.8 # \ 4.4 #
3-hour (PSD increment is 25 ug/m3):						
EPA's paired in space and time	17.8	14.8	16.9 \ 14.9	14.3	14.4	14.6 \ 12.7
Paired in space only	12.7	8.8	14.0 \ 10.9	11.0	7.0	12.2 \ 9.7

* For 2002, numbers at left are based upon the protocol. Numbers at right are based upon 2002-2003 actual emissions.
# See pages 32 and 33 for an explanation and illustration of the larger number when using the paired-in-space-only method.

TRNP–North Unit. Modeling results indicate:

1. No deterioration exceeding the increments when replacing 2000-2001 actual emissions with 2002-2003 actual emissions and when using 2002 weather data. Attainment of the PSD short-term sulfur dioxide increment provides margins for additional emissions of sulfur dioxide.

2. Increases in margins when excluding two sources granted FLM CONAI.

3. Deterioration pursuant to EPA's method is greater than deterioration pursuant to the paired-in-space-only method. The results of the State's method are consistent with the trend in monitoring data for a site in the North Unit.

Table 9. Highest second highest deterioration in sulfur dioxide concentrations (ug/m3) for the TRNP–North Unit.

METHOD of tracking changes in concentrations at a receptor due to changes in emissions after PSD baseline	WITH sources granted FLM CONAI and a PSD increment variance			WITHOUT sources granted FLM CONAI and a PSD increment variance		
Meteorological data	2000	2001	2002 *	2000	2001	2002 *
24-hour (PSD increment is 5 ug/m3):						
EPA's paired in space and time	3.6	3.6	5.1 \ 4.5	3.2	3.0	4.4 \ 3.7
Paired in space only **	-13.3	-8.3	-3.3 \ -4.3	-14.2	-8.7	-4.0 \ -4.9
3-hour (PSD increment is 25 ug/m3):						
EPA's paired in space and time	12.1	11.4	14.0 \ 14.0	9.8	11.3	13.9 \ 13.9
Paired in space only **	-64.9	-37.0	-22.1 \ -26.0	-67.7	-38.6	-24.6 \ -27.6

* For 2002, numbers at left are based upon the protocol. Numbers at right are based upon 2002-2003 actual emissions.
** Negative numbers indicate that current sulfur dioxide concentrations are less than the baseline concentration, which is likely due to a substantial decline in emissions by flares and treaters.

TRNP–Elkhorn Ranch Unit. Modeling results indicate:

1. No deterioration exceeding the increments. Attainment of the PSD short-term sulfur dioxide increment provides margins for additional emissions of sulfur dioxide.

2. Minor increases in margins when excluding two sources granted FLM CONAI.

3. Deterioration pursuant to EPA's method is greater than deterioration pursuant to the paired-in-space-only method.

Table 10. Highest second highest deterioration in sulfur dioxide concentrations (ug/m3) for the TRNP–Elkhorn Ranch.

METHOD of tracking changes in concentrations at a receptor due to changes in emissions after PSD baseline	WITH sources granted FLM CONAI and a PSD increment variance			WITHOUT sources granted FLM CONAI and a PSD increment variance		
Meteorological data	2000	2001	2002 *	2000	2001	2002 *
24-hour (PSD increment is 5 ug/m3):						
EPA's paired in space and time	0.6	1.0	1.2 \ 0.7	0.6	0.9	0.9 \ 0.7
Paired in space only **	-7.8	-12.8	-6.2 \ -8.0	-8.4	-13.0	-7.0 \ -8.5
3-hour (PSD increment is 25 ug/m3):						
EPA's paired in space and time	9.8	5.1	7.9 \ 5.8	8.1	4.4	7.0 \ 5.7
Paired in space only **	-34.6	-32.3	-18.9 \ -22.6	-35.6	-33.2	-21.4 \ -24.4

* For 2002, numbers at left are based upon the protocol. Numbers at right are based upon 2002-2003 actual emissions.
** Negative numbers indicate that current sulfur dioxide concentrations are less than the baseline concentration, which is likely due to a substantial decline in emissions by flares and treaters.

Lostwood Wilderness Area. Modeling results indicate:

1. No deterioration exceeding the increments. Attainment of the PSD short-term sulfur dioxide increment provides margins for additional emissions of sulfur dioxide.

2. Minor increases in margins when excluding two sources granted FLM CONAI.

3. Twenty four-hour and 3-hour deterioration pursuant to EPA's method are sometimes less than deterioration pursuant to the paired-in-space-only method. (See pages 32 and 33 of this report.)

Table 11. Highest second highest deterioration in sulfur dioxide concentrations (ug/m3) for the Lostwood Wilderness Area.

METHOD of tracking changes in concentrations at a receptor due to changes in emissions after PSD baseline	WITH sources granted FLM CONAI and a PSD increment variance			WITHOUT sources granted FLM CONAI and a PSD increment variance		
Meteorological data	2000	2001	2002 *	2000	2001	2002 *
24-hour (PSD increment is 5 ug/m3):						
EPA's paired in space and time	2.6	4.2	3.2 \ 2.5	2.5	3.6	2.6 \ 2.1
Paired in space only	2.1	1.9	3.3 # \ 2.5	1.8	1.7	2.7 # \ 2.1
3-hour (PSD increment is 25 ug/m3):						
EPA's paired in space and time	10.3	12.3	8.7 \ 7.1	9.8	10.6	7.6 \ 6.1
Paired in space only	7.3	5.4	9.6 # \ 6.8	6.8	5.2	9.4 # \ 6.7 #

* For 2002, numbers at left are based upon the protocol. Numbers at right are based upon 2002-2003 actual emissions.
\# See pages 32 and 33 for an explanation and illustration of the larger number when using the paired-in-space-only method.

Medicine Lake NWA. Modeling results indicate:

1. No deterioration exceeding the increments. Attainment of the PSD short-term sulfur dioxide increment provides margins for additional emissions of sulfur dioxide.

2. Minor increases in margins when excluding two sources granted FLM CONAI.

3. Deterioration pursuant to EPA's method is greater than deterioration pursuant to the paired-in-space-only method.

Table 12. Highest second highest deterioration in sulfur dioxide concentrations (ug/m3) for the Medicine Lake NWA.

METHOD of tracking changes in concentrations at a receptor due to changes in emissions after PSD baseline	WITH sources granted FLM CONAI and a PSD increment variance			WITHOUT sources granted FLM CONAI and a PSD increment variance		
Meteorological data	2000	2001	2002 *	2000	2001	2002 *
24-hour (PSD increment is 5 ug/m3):						
EPA's paired in space and time	1.3	1.7	1.8 \ 1.5	1.1	1.5	1.7 \ 1.4
Paired in space only **	0.1	1.7	1.2 \ 0.6	-8.4	-13.0	-7.0 \ 0.4
3-hour (PSD increment is 25 ug/m3):						
EPA's paired in space and time	4.9	6.1	7.6 \ 7.1	4.1	5.7	7.3 \ 6.8
Paired in space only	4.4	3.4	3.6 \ 3.1	3.9	3.0	3.3 \ 2.9

* For 2002, numbers at left are based upon the protocol. Numbers at right are based upon 2002-2003 actual emissions.
** Negative numbers indicate that current sulfur dioxide concentrations are less than the baseline concentration, which is likely due to a substantial decline in emissions by flares and treaters.

Fort Peck Reservation. Modeling results indicate:

1. No deterioration exceeding the increments. Attainment of the PSD short-term sulfur dioxide increment provides margins for additional emissions of sulfur dioxide.

2. Minor increases in margins when excluding two sources granted FLM CONAI.

3. Twenty four-hour deterioration pursuant to EPA's method is sometimes less than deterioration pursuant to the paired-in-space-only method. (See pages 32 and 33 of this report.)

Table 13. Highest second highest deterioration in sulfur dioxide concentrations (ug/m3) for the Fort Peck Reservation.

METHOD of tracking changes in concentrations at a receptor due to changes in emissions after PSD baseline	WITH sources granted FLM CONAI and a PSD increment variance			WITHOUT sources granted FLM CONAI and a PSD increment variance		
	2000	2001	2002 *	2000	2001	2002 *
24-hour (PSD increment is 5 ug/m3):						
EPA's paired in space and time	2.7	1.6	2.4 \ 1.7	2.4	1.4	2.1 \ 1.5
Paired in space only	2.8 #	1.5	2.4 \ 2.0 #	2.7 #	1.4	2.2 # \ 1.9 #
3-hour (PSD increment is 25 ug/m3):						
EPA's paired in space and time	9.4	7.2	6.6 \ 6.1	9.2	6.4	6.2 \ 5.8
Paired in space only	6.8	6.3	6.1 \ 5.0	6.0	5.4	5.4 \ 4.5

* For 2002, numbers at left are based upon the protocol. Numbers at right are based upon 2002-2003 actual emissions.
[#] See pages 32 and 33 for an explanation and illustration of the larger number when using the paired-in-space-only method.

9.0 Interpretation of protocol year 2002 results.

Two sections of this report ("Model accuracy tests" and "Trends in 2000 – 2002 emissions") illustrated significant over prediction bias in predicted sulfur dioxide concentrations when using 2000-2001 actual emissions and 2002 meteorological data. For example, the predicted PSD 24-hour concentrations at all receptors in the South Unit of the TRNP were larger than the second highest observed concentration at the site of the monitor during 2002.

Another section ("Calculating deterioration") illustrated that predicted 24-hour sulfur dioxide baseline concentrations at receptors in the South Unit when using baseline emissions and 2002 meteorological data also were larger than the second highest observed concentration at the site of the monitor during 2002. But predicted 24-hour sulfur dioxide baseline concentrations when using 2000 and 2001 meteorological data were not larger than the second highest 24-hour observed concentrations at the site of the monitor during those years.

> The department began reforming its modeling of sulfur dioxide emissions during the mid 1990s. Since 2000, it has reviewed many aspects of modeling with CALMET and CALPUFF, received comment and improved numerous data inputs.
>
> Under prediction and over prediction of daily sulfur dioxide concentrations illustrated by the time-series plots in figure 4 and in Appendix C and results of accuracy tests, provide impetus for exploration for additional improvements in model inputs.

This section examines monitoring data from 2002 for evidence of persistent weather events when the largest observed concentrations occurred on back to back days. It also establishes the Julian days within 2002 on which predicted 24-hour deterioration exceeded the PSD Class I 24-hour increment when executing the protocol.

9.1 Persistent weather events.

The magnitude and timing of observed sulfur dioxide concentrations – and predicted concentrations – depend on the temporal sequence and spatial variation of meteorological conditions preceding and during concentration averaging periods as well as the locations and sulfur dioxide emissions of sources.

A few weather events occurred during years 2000, 2001 and 2002 which resulted in extended periods (multiple back to back days) of higher daily observed sulfur dioxide concentrations. These events are delineated among the data in the tables in Appendix B. One event during 2002 resulted in an exceptional extended period of 21 days (Julian days 234 through 255) at the site of the monitor in the South Unit of TRNP.

9.2 Weather events causing exceedances of the 24-hour increment.

Given the two weather events of highest predicted concentrations as shown in figure 10, another question posed is: What is the spatial distribution of predicted exceedances of the PSD Class I 24-hour sulfur dioxide increment under the protocol when using 2002 meteorological data? An exceedance occurs when the predicted deterioration is larger than the PSD increment. The spatial distribution of exceedances following EPA's current method of pairing predicted concentrations due to PSD baseline emissions and due to current emissions in both time (day) and space (receptor) is shown in figure 11. The spatial distribution following the Alternate method of pairing these concentration in space only is shown in figure 12.

The data in the charts reveal that, by either method, receptors had 1 or 2 exceedances, and no receptor had 3 or more exceedances. All exceedances under EPA's method occur on Julian days 78 and 136. All exceedances under the Alternate method during 2002, which track to a baseline concentration established by also modeling 2002 meteorological data, occur on Julian days 78 and 250.

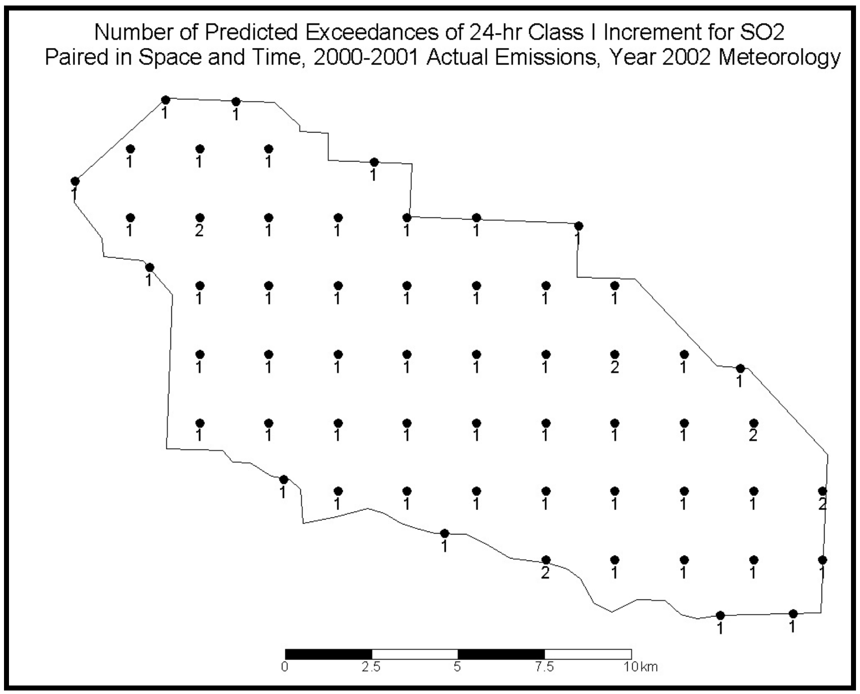


Figure 11.

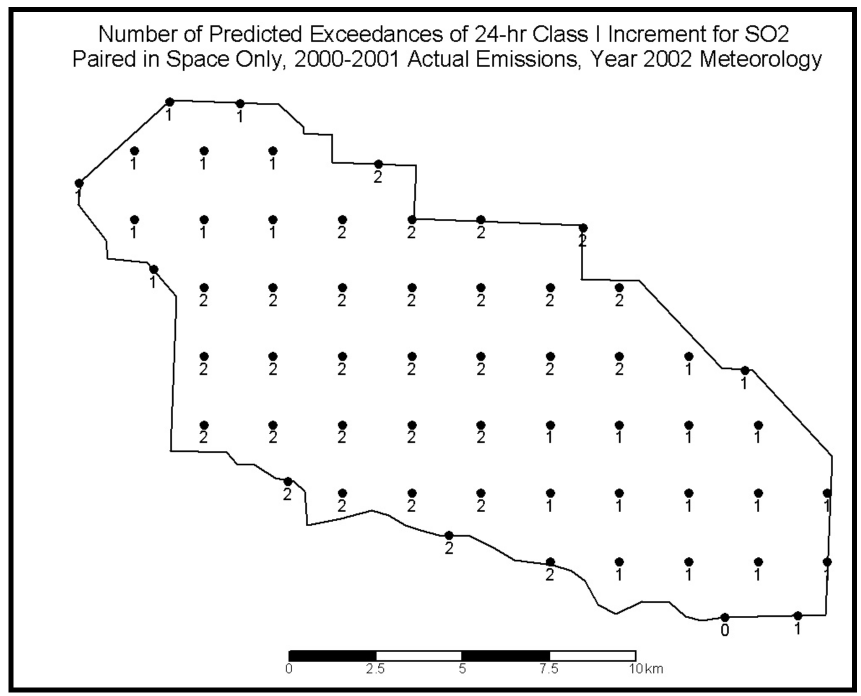


Figure 12.

Irrespective of method of calculating deterioration, the Julian days of highest predicted 24-hour concentrations, when using 2000-2001 actual emissions and 2002 meteorological data, are shown in figure 13. Similarly, the days of second highest predicted 24-hour concentrations are shown in figure 14. The charts reveal that the highest and second highest predicted 24-hour concentrations occur on either Julian day 78 or Julian day 250. [Note. The highest and second highest predicted 24-hour concentrations when using 2002-2003 actual emissions and 2002 meteorological data also occurred on either Julian day 78 or 250.]

If under the Alternate method there had been 3 exceedances of the PSD Class I 24-hour increment, the third highest exceedance would have occurred on the Julian day having the third highest 24-hour predicted concentration due to current emissions; similarly, for the fourth exceedance, and so on. Under EPA's paired in space and time method, exceedances can occur on Julian days which do not rank among the highest of predicted 24-hour concentrations due to current emissions. (See pages 28 - 33 of this report.)

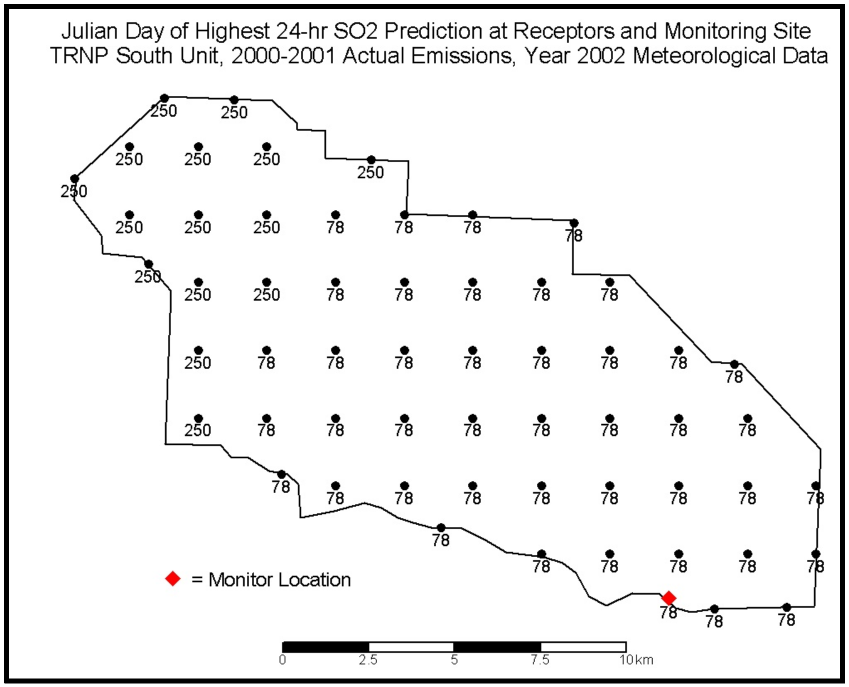


Figure 13.

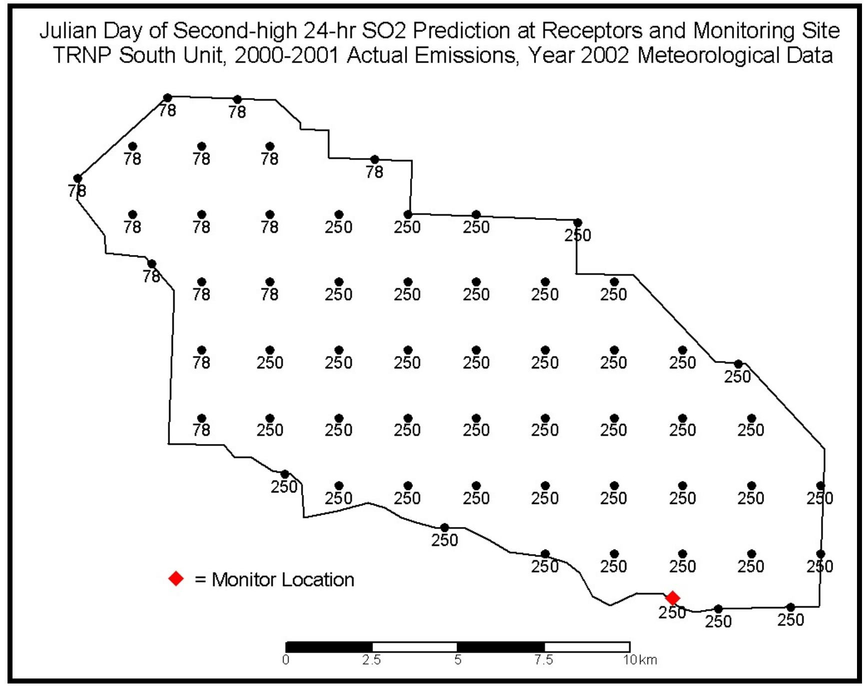


Figure 14.

9.3 <u>Spatial variation of predicted second highest 24-hour ΔXs</u>.

The CAA and rules allow one exceedance per year of 24-hour and 3-hour PSD Class I sulfur dioxide increments, with exceptions provided. (See NDAC 33-15-15-01(4.j).) An exceedance occurs when predicted deterioration is larger than the increment. EPA's current paired in space and time method and the Alternate method of calculating increment exceedances are explained on pages 25 - 28 of the protocol and on pages 29 - 33 of this report. The second highest predicted deterioration of daily (24-hour) concentrations due to changes in emitted sulfur dioxide since PSD baseline when using 2002 meteorological data are provided in figure 15 when using EPA's method and in figure 16 when using the Alternate method. Similarly, the second highest predicted deterioration of 3-hour concentrations are provided in Appendix G.

The numeric values of second highest predicted 24-hour deterioration are higher in the northwest and southeast regions of the South

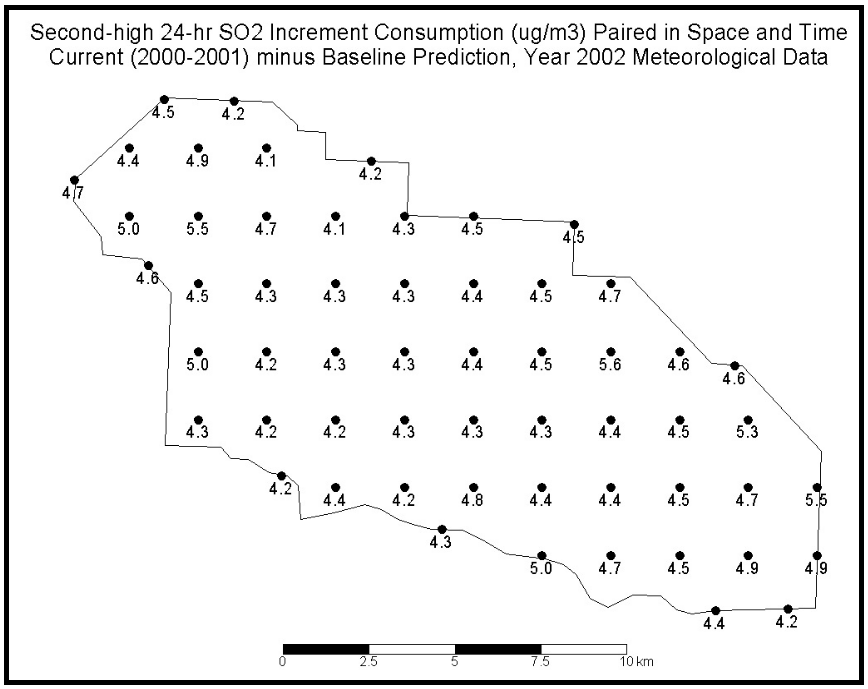


Figure 15.

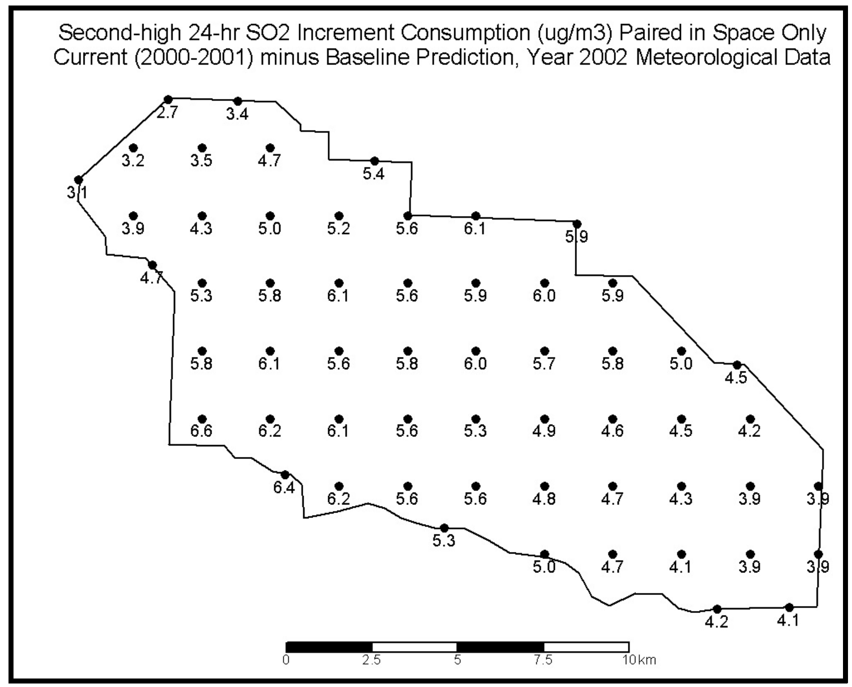


Figure 16.

Unit when using 2002 meteorological data and EPA's current method, and the values are higher in the remaining region when using the Alternate method.

9.4 Comments.

As shown in tables in the previous section of this report, one or two predicted exceedances of the PSD 24-hour sulfur dioxide increment occurred at receptors in the South and North Units of TRNP when using 2000-2001 actual emissions and 2002 meteorological data. This section identified the Julian days of year 2002 when exceedances occurred at the South Unit.

Julian day 136 was one of two days on which exceedances occurred in the South Unit when using EPA's current method of calculating deterioration. However, the 24-hour observed concentration at the site of the monitor in the South Unit on Julian day 136 does not rank among the largest 40 daily concentrations during 2002. (See Appendix B.)

Julian day 250 was one of two days on which exceedances occurred in the South Unit when using the Alternate method of calculating deterioration. Day 250 is among an extended episode of larger daily observed concentrations at the site of the monitor in the South Unit.

All highest and highest second highest exceedances occur on one or two days – whether using EPA's current method or the Alternate method of calculating deterioration. Thus, the total number of exceedances among receptors in a Class I area is a misleading indicator of the degree of potential violation of the 24-hour increment. A better indicator is the number of 24-hour, or 3-hour, averaging periods during which an exceedance occurs at one or more receptors in the area.

Larger 3-hour and 24-hour sulfur dioxide concentrations occur when emissions are not diluted in air; for example, when wind speeds are calm or light and variable. Higher wind speeds within the boundary layer and at the surface provide larger volumes of air for mixing of the emitted sulfur dioxide; as a consequence, the short-term sulfur dioxide concentrations are smaller. Some of the largest observed 24-hour sulfur dioxide concentrations at sites of monitors occurred during extended periods (multiple back to back days), which suggests persistent weather conditions that did not fully dilute the emitted sulfur dioxide.

10.0 Supplemental information and analyses.

An example of using observed sulfur dioxide concentrations at sites of monitors for testing model accuracy was reported at the "7th International Conference on Harmoni[z]ation with Atmospheric Dispersion Modeling for Regulatory Purposes." (See paper by Irwin, John S., et al. A comparison of CALPUFF air quality simulation results with monitoring data for Krakow Poland. Pages 217 through 221.) The department's use of observed sulfur dioxide concentrations for the model accuracy testing described in this report is consistent with Irwin's paper.

10.1 Amounts of over prediction.

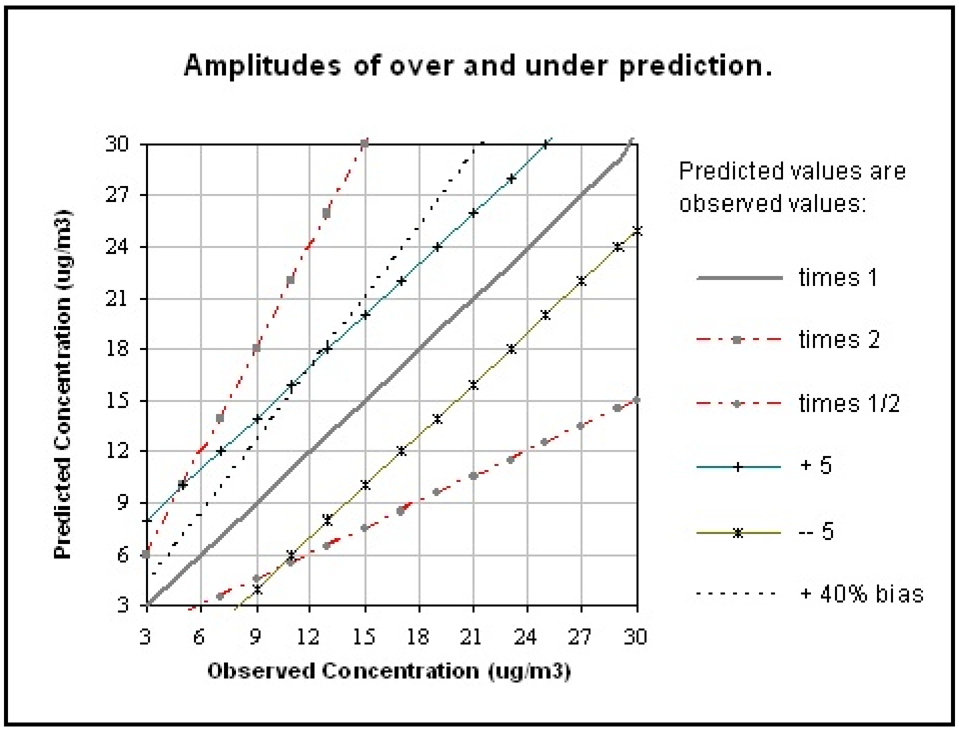


Figure 17.

In this report, model prediction bias is illustrated with averaged accuracy ratios. An accuracy ratio is calculated by dividing a predicted concentration with a paired observed concentration. The 25 highest predicted and observed concentrations were used, and the average of the 25 ratios was calculated. Twenty four-hour time averaged observed concentrations are based upon hourly concentrations obtained with monitoring equipment. (See H of the protocol and Appendix B of this report.)

An inherent aspect of these averaged accuracy ratios is that the amounts of under or over prediction increase as observed concentrations increase. This aspect of the ratios is illustrated in figure 17 for averaged accuracy ratios of 0.5, 1.4 (+40% bias) and 2.0. The ratio of 2.0, which is a factor of two, is often cited by EPA as an upper limit of acceptable model accuracy performance.

When the accuracy ratio is 1.4, the amount of over prediction is 4 ug/m3 when the observed concentrations is 10 ug/m3. Generally, when accuracy ratios are 1.4

and larger, amplitudes of over prediction exceed 2 ug/m3 when observed concentrations are 5 ug/m3 and larger. Because the PSD Class I 24-hour sulfur dioxide increment is 5 ug/m3, the amount of over prediction of 2 ug/m3 or more have onerous implications on ascertaining attainment of this increment.

10.2 Optional math for accuracy tests.

Air quality models have had poor skill in predicting concentrations paired in space and time with observed concentrations. For example, ". . . the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. . . . However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations . . ." (See paragraph b, section 10.1.2 of 40 CFR 51, Appendix W.) These observations are adopted in the accuracy test provided by the protocol and the test math previously described in this report.

Given the apparent frequent agreement in daily timing of larger observed sulfur dioxide concentrations and larger predicted sulfur dioxide concentrations (see pages 17 - 19 of this report), an optional method for calculating the accuracy of predicted concentrations follows. Here again, source hourly CEM sulfur dioxide emissions were used when available.

Rather than pairing the highest predicted sulfur dioxide concentration to the highest observed sulfur dioxide concentration and so forth (see pages 20 - 28 of this report), (A) the 25 largest observed 24-hour concentrations are paired, respectively, with time concurrent predicted concentrations and (B) the 25 largest predicted 24-hour concentrations are paired, respectively, with time concurrent observed concentrations. Table 14 and figure 18 illustrate such data for the site of the monitor at the South Unit of TRNP during year 2000. The word "original" in the table and figure refer to the accuracy test described by the protocol. As shown on table 14 and figure 18, seven pairs of predicted and observed concentrations appear in both type A and type B data sets.

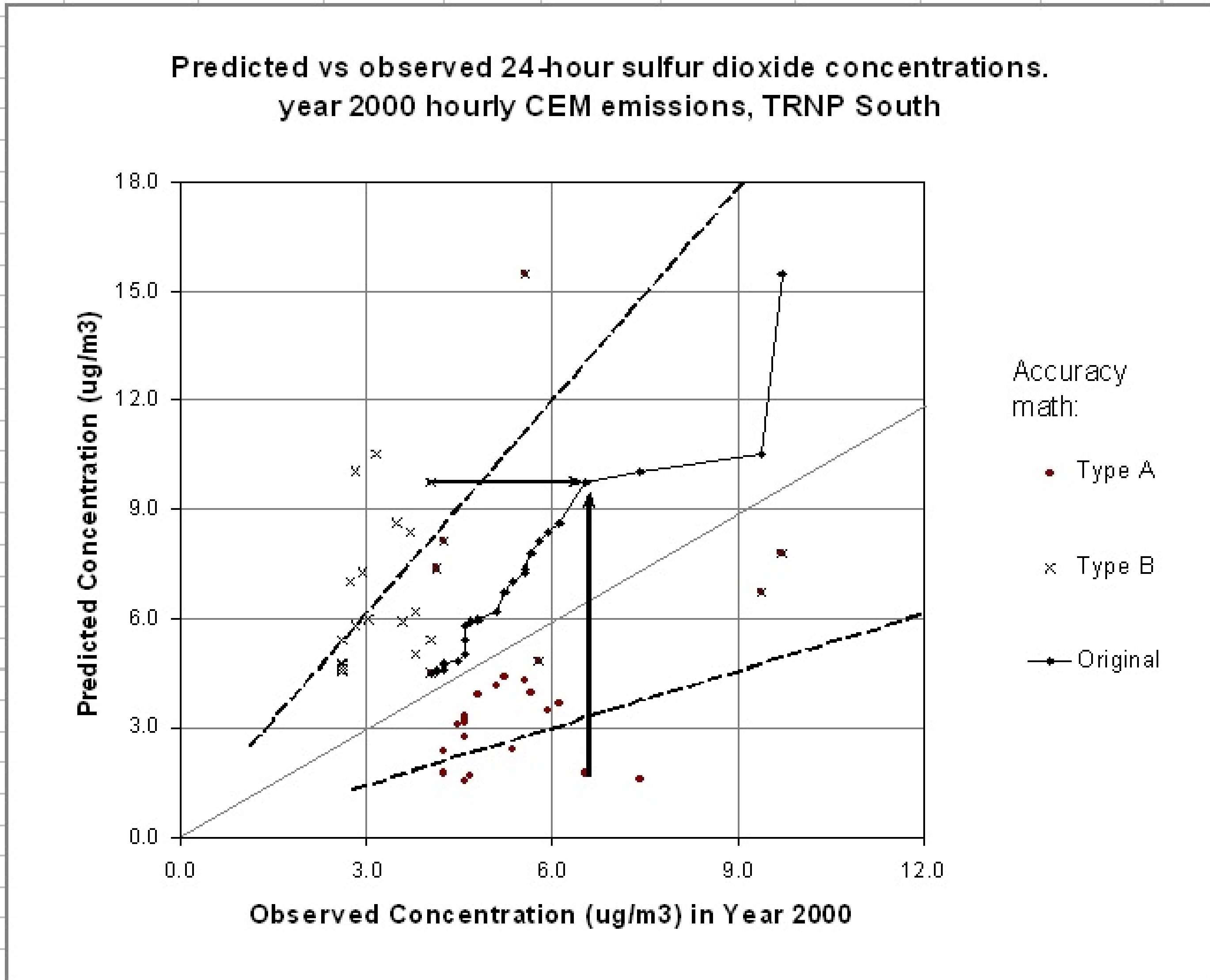
Ratios of the time concurrent predicted and observed concentrations are calculated. For type A ratios, each respective time paired predicted concentration is divided by the observed concentration; and for type B ratios, each predicted concentration is also divided by the respective time paired observed concentration. The 25 ratios under both types are averaged. This math is illustrated in table 15. The procedure includes the timing of predicted concentrations, as well as the amplitudes of predicted concentrations, in accuracy math.

The models (CALMET and CALPUFF) do not consistently over or under predict observed sulfur dioxide time-concurrent concentrations. As shown in table 15, the largest observed 24-hour concentrations are greater than time-concurrent predicted concentrations (type A). But, the largest of predicted 24-hour concentrations are substantially greater than time-concurrent observed concentrations (type B).

Table 14. Example of optional math for model accuracy tests. TRNP South, Year 2000.

(A) Rank	Obs	Time Concurrent Pred+1.5	Pred/Obs	(B) Rank	Pred+1.5	Time Concurrent Obs	Pred/Obs	Original Rank Pred/Obs
1	9.72	7.81	0.80	1	15.50	5.57	2.78	1.59
2	9.39	6.74	0.72	2	10.49	3.17	3.31	1.12
3	7.42	1.61	0.22	3	10.05	2.84	3.54	1.36
4	6.55	1.78	0.27	4	9.73	4.04	2.41	1.49
5	6.11	3.65	0.60	5	8.65	3.49	2.48	1.42
6	5.95	3.45	0.58	6	8.40	3.71	2.27	1.41
7	5.79	4.82	0.83	7	8.13	4.26	1.91	1.40
8	5.68	3.99	0.70	8	7.81	9.72	0.80	1.38
9	5.57	4.31	0.77	9	7.41	4.15	1.79	1.33
9	5.57	15.50	2.78	10	7.28	2.95	2.47	1.31
11	5.35	2.43	0.45	11	7.04	2.73	2.58	1.32
12	5.24	4.41	0.84	12	6.74	9.39	0.72	1.29
13	5.13	4.16	0.81	13	6.20	3.82	1.62	1.21
14	4.80	3.94	0.82	14	5.99	3.06	1.96	1.25
15	4.69	1.70	0.36	15	5.95	3.60	1.65	1.27
16	4.59	3.32	0.72	16	5.85	2.84	2.06	1.27
17	4.59	2.78	0.61	17	5.45	2.62	2.08	1.19
18	4.59	1.57	0.34	18	5.44	4.04	1.35	1.18
19	4.59	3.16	0.69	19	5.02	3.82	1.31	1.09
20	4.48	3.13	0.70	20	4.82	5.79	0.83	1.08
21	4.26	2.34	0.55	21	4.80	2.62	1.83	1.13
22	4.26	8.13	1.91	22	4.74	2.62	1.81	1.11
23	4.26	1.75	0.41	23	4.65	2.62	1.78	1.09
24	4.15	7.41	1.79	24	4.56	2.62	1.74	1.10
25	4.04	4.51	1.12	25	4.51	4.04	1.12	1.12
Averages			0.82				1.93	1.26

Obs = observed 24-hour concentration (ug/m3). Pred = model predicted 24-hour concentration (ug/m3).



Predicted vs observed 24-hour sulfur dioxide concentrations.
year 2000 hourly CEM emissions, TRNP South
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3) in Year 2000
18.0
15.0
12.0
9.0
6.0
3.0
0.0
0.0
3.0
6.0
9.0
12.0
Accuracy math:
Type A
Type B
Original

Figure 18.

[Note. The department did not use the NWS data only option provided by the protocol. Results using this option could be used to verify that use of the ADAS enhanced RUC-2 data improves the timing accuracy of predicted concentrations.]

10.3 Background concentration for accuracy assessments.

Results of accuracy tests and other comparisons of predicted sulfur dioxide concentrations and observed sulfur dioxide concentrations rely upon the background sulfur dioxide concentration for the predicted concentrations as 1.5 ug/m3. (See pages 21 - 24 in the protocol.) A background concentration for sulfur dioxide is added to predicted sulfur dioxide concentrations because inventories of emitted sulfur dioxide for modeling do not include all sources within the modeling domain. In addition, sulfur dioxide is transported by winds into the modeling domain.

Another question might be: Would results of accuracy tests change significantly if the background concentration was 1.0 rather than 1.5 ug/m3? [Note. Previous accuracy testing by the department in 2002 and 2003 assumed that the background sulfur dioxide concentration was 0 ug/m3.]

The question is answered by substitution of 1.0 for 1.5 ug/m3 in table 14 and recalculating ratios of predicted to observed 24-hour sulfur dioxide concentrations. The results are presented in table 16; the ratios decreased about 0.10 or 10 percent by comparison to ratios in table 14. Predicted and observed 24-hour sulfur dioxide concentrations in TRNP–S and TRNP–N are small – only about 5 % and 3% of all concentrations, respectively, are larger than 5 ug/m3, which is the PSD Class I 24-hour increment. (See Appendix H of the protocol.) Because predicted and observed 24-hour concentrations at rural Dunn Center and rural Hannover are larger, accuracy ratios for these sites would not decrease as much.

Table 15. Comparison of results of options for accuracy test math. *

Year	Original math	Optional math	
		Type A	Type B
2000	1.26	0.82	1.93
2001	1.01	0.55	1.91
2002	1.31	0.71	2.19

* Test conditions: hourly CEM emissions, site of the monitor in TRNP South Unit and 24-hour period.

Table 16. Comparison of results of accuracy tests when using a background concentration for sulfur dioxide as 1.0 ug/m3. *

Year	Original math	Optional math	
		Type A	Type B
2000	1.16	0.72	1.79
2001	0.91	0.46	1.75
2002	1.22	0.63	2.05

* Test conditions: same as table 15.

10.4 Options in select model control-file inputs.

When bias occurs in predicted sulfur dioxide concentrations at current emissions, bias also occurs in predicted changes in concentrations. (See Appendix B of the protocol.) Exceptional model over prediction on individual daily events matters when those events are the highest and highest second highest predicted concentrations and calculated deterioration. (See figures 6 and 10 in this report.)

EPA has known that when winds are calm (stagnant air) models can predict unrealistically large concentrations.

> CALPUFF can predict simulated concentrations that are greater than plume model simulated concentrations during periods of calm winds and wind reversals. (See pages 6, 17, and 76-80 in IWAQM's Phase 2 report.)
>
> "[The] complex interaction of transport, vertical mixing, and dispersion have an effect on concentrations with respect to downwind distances in CALPUFF. Occasionally, the accumulation of mass released over several hours will be transported in such a manner that the combined effect is to produce sharp localized maxima in simulated concentration values. The occurrence of such events is not predictable. . . . Calm winds play a part in these events. These maxima seem to occur at most locations in the receptor network, at all downwind distances. When they occur, they seem to affect in particular the results of the shorter averaging periods." (U.S. EPA, December 1998. A comparison of CALPUFF with ISC3. Publication No. EPA-454/R-98-020, Office of Air Quality Planning and Standards, Research Triangle Park. Page 20.)
>
> ". . . [modeled] concentrations may become unrealistically large when wind speeds less than 1 m/s are input to the [steady-state Gaussian plume model]" because the ". . . model does not apply during calm conditions, . . . Therefore, the [steady-state modeling] procedures disregard hours which are identified as calm." (See section 9.3.4.1(a) of Appendix W attached to 40 CFR Part 51.)

This question emerges: What were the synoptic, surface wind and boundary layer wind conditions during Julian days 234 through 255 in 2002 and other extended periods of observed sulfur dioxide impact at monitoring sites? The department contracted with WindLogics, Inc., to describe the synoptic and pollutant transport characteristics of the enhanced RUC-2 data from central to western North Dakota during these days. A report by WindLogics is pending.

When comparing predicted sulfur dioxide concentrations to time-concurrent observed sulfur dioxide concentrations with time-series graphs, the graphs vividly illustrate over prediction of some observed concentrations; for example, see figure 4 and Appendix C.

- Likewise, graphs of largest predicted concentrations paired with largest observed concentrations also illustrate over prediction; for example, see figure 6 and Appendix E.

- In addition, accuracy test ratios are not consistent year-to-year (see tables 6 and 14), since ratios at individual sites widely vary from year-to-year. And, the ratio for Dunn Center is not always larger that the ratio for the TRNP–S; the ratio for Hannover is not always larger than the ratio for Dunn Center. [Note. Previous model results accuracy assessments that were completed by the department used only one year of predicted concentrations and observed concentrations.]

- Some of the largest observed 24-hour concentrations occur on back-to-back days when weather is likely stagnant (see Appendix B). [Note. Previous model results accuracy assessments did not examine observed concentrations for evidence of fumigation events.]

Another question occurs: In retrospect, are there technically better choices for values or settings of some CALMET and CALPUFF control-file variables that would result in improved agreement between predicted sulfur dioxide concentrations and observed concentrations in western North Dakota. For example,

- There are numerous oil and gas production flares and treaters that are located short distances from Class I areas; especially the South Unit of TRNP. (See page 55 of the protocol.) The User's Guide for CALPUFF describes use of "slugs" rather than "puffs" and indicates that, "[u]nlike the slug model, segmented plume models do not properly treat low wind speed conditions . . .", especially when model receptors are less than 10 kilometers from sources. (See pages 2-7 through 2-22.) When plumes of emitted sulfur dioxide are represented by the CALPUFF model as slugs rather than puffs, input variable MSLUG is set to 1 rather than 0.

APPENDIX A. Wind frequencies at sites of monitors.

The North Dakota Department of Health operates equipment for monitoring contaminants in ambient air at a site in the South Unit of the TRNP and at a rural site near Dunn Center. This appendix provides illustrations of:

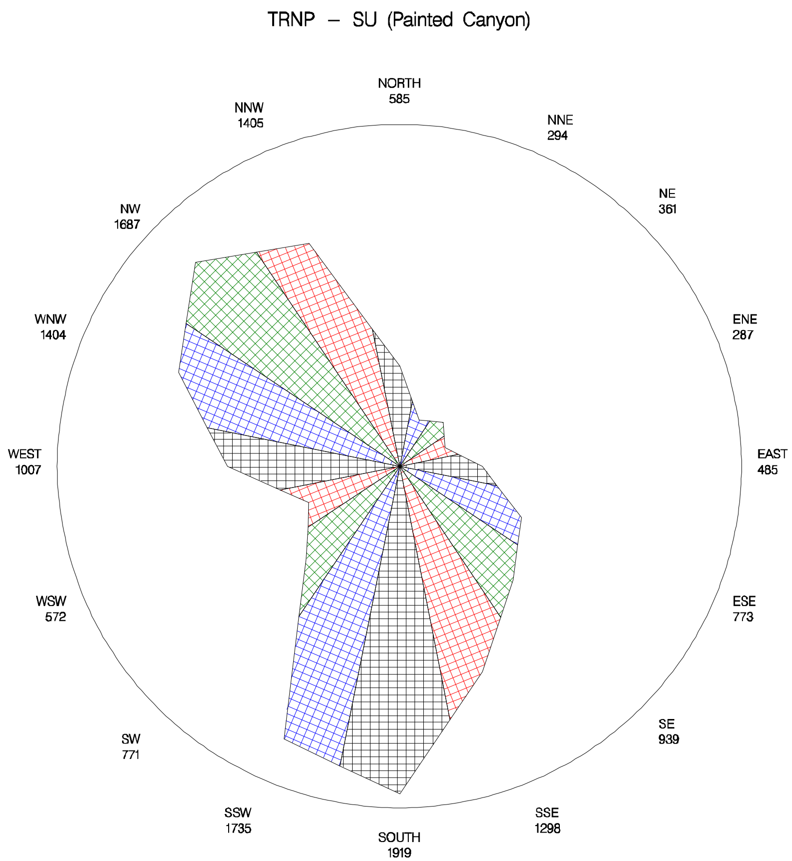
- frequencies of wind direction for each of sixteen wind direction sectors and
- frequencies of detected hourly sulfur dioxide for each of those wind sectors. [1]

The illustrations include data for years 2000 and 2001. Because operation of a site in the North Unit of TRNP began during 2001, frequency data for this site are not included.

---

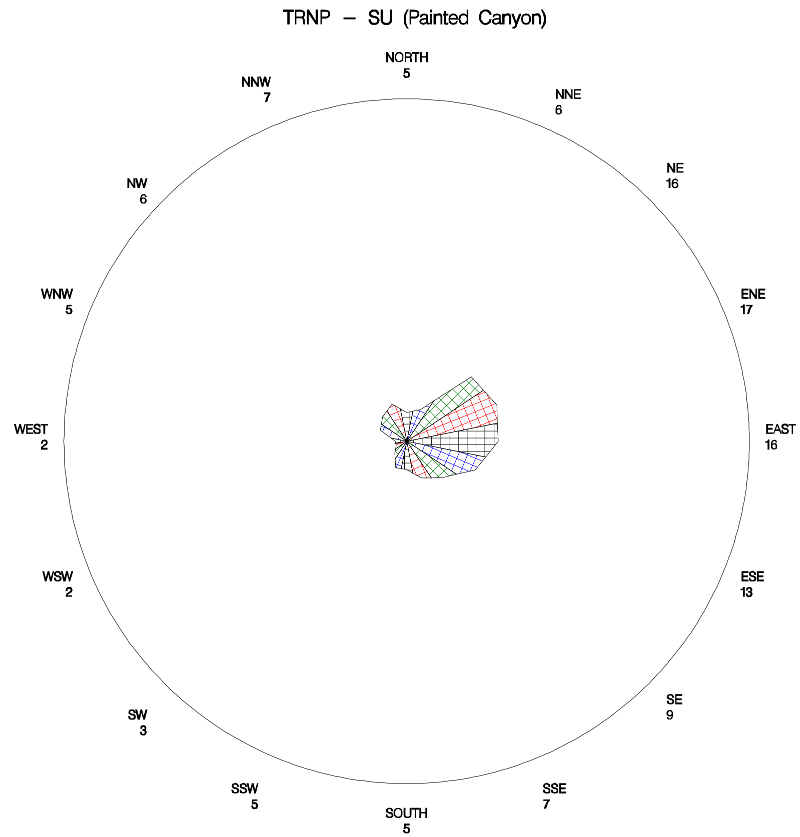
[1] The frequencies include hourly sulfur dioxide concentrations larger than 1 ppb (2.62 ug/m3). Due to instrument calibration methods, the practical lower detection level is 1.5 ppb. (See Appendix H of the protocol.)

Wind Direction Frequency
by Wind Sector
Period of Record: 2000 - 2001



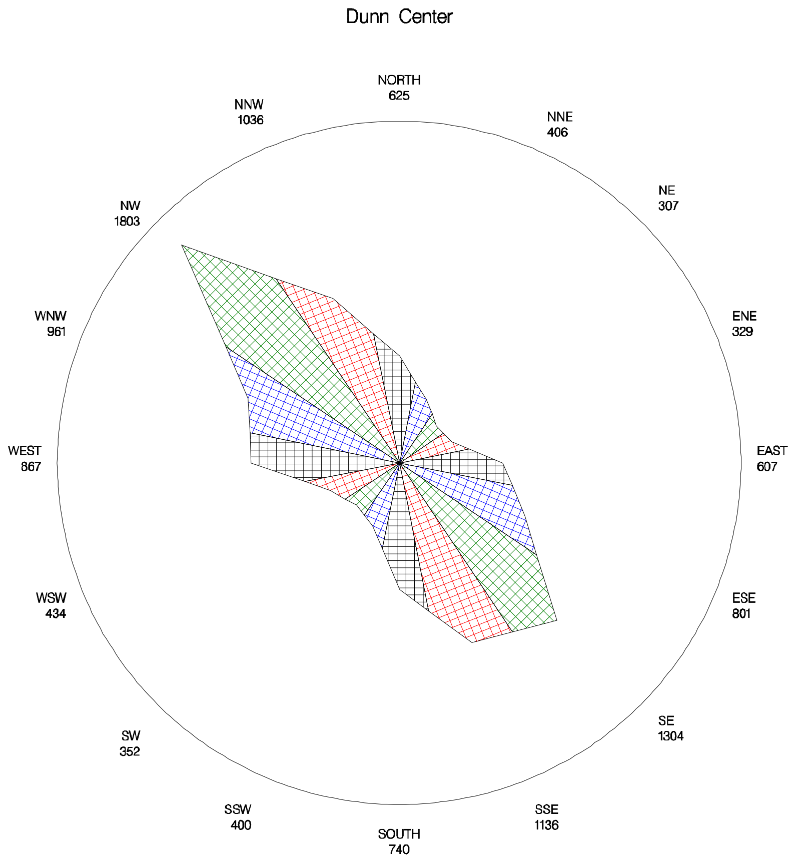
Wind Frequencies for Wind Speeds Greater than 5 mph
Circle Radius = 2000 hours

Percent of Time Sulfur Dioxide
Detected for each Wind Sector
Period of Record: 2000 - 2001



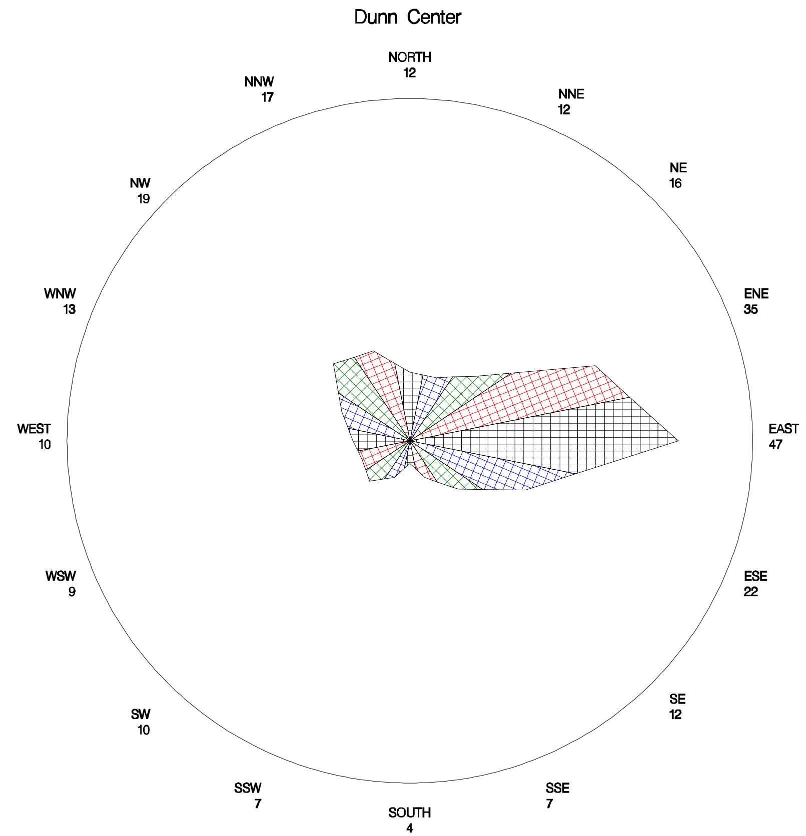
Circle Radius = 60 Percent

Wind Direction Frequency
by Wind Sector
Period of Record: 2000 - 2001



Wind Frequencies for Wind Speeds Greater than 5 mph
Circle Radius = 2000 hours

Percent of Time Sulfur Dioxide
Detected for each Wind Sector
Period of Record: 2000 - 2001



Circle Radius = 60 Percent

APPENDIX B. Tables of the largest observed 24-hour sulfur dioxide concentrations.

A map of the locations of four sulfur dioxide monitors where observed sulfur dioxide concentrations were obtained during years 2000, 2001 and 2002 is attached.

This appendix also contains tables of the largest observed 24-hour sulfur dioxide concentrations at each of the four monitoring sites for years 2000, 2001, and 2002. Data in these tables are the same data that are provided in Appendix H of the protocol. However, the data, which are the 40 largest 24-hour observed sulfur dioxide concentrations, are arranged sequentially by Julian day through the year for each monitoring site. [Note. The department established a site for monitoring sulfur dioxide and other parameters in the North Unit of TRNP during 2001; thus, a complete year of data for 2001 was not obtained.]

- This arrangement demonstrates occurrences of weather events, as sequence of days, for larger 24-hour sulfur dioxide concentrations; for example, note the long sequence of days during 2002 at the monitoring site in the South Unit of TRNP.

- The arrangements also demonstrates that the locations of monitors at rural Hannover and rural Dunn Center are often in the path of sulfur dioxide plumes on days immediately preceding and/or during days of larger sulfur dioxide concentrations at the locations of monitors in the South and North Units of TRNP.

Map of the sites of sulfur dioxide monitors. Data obtained from these locations are used through this report.

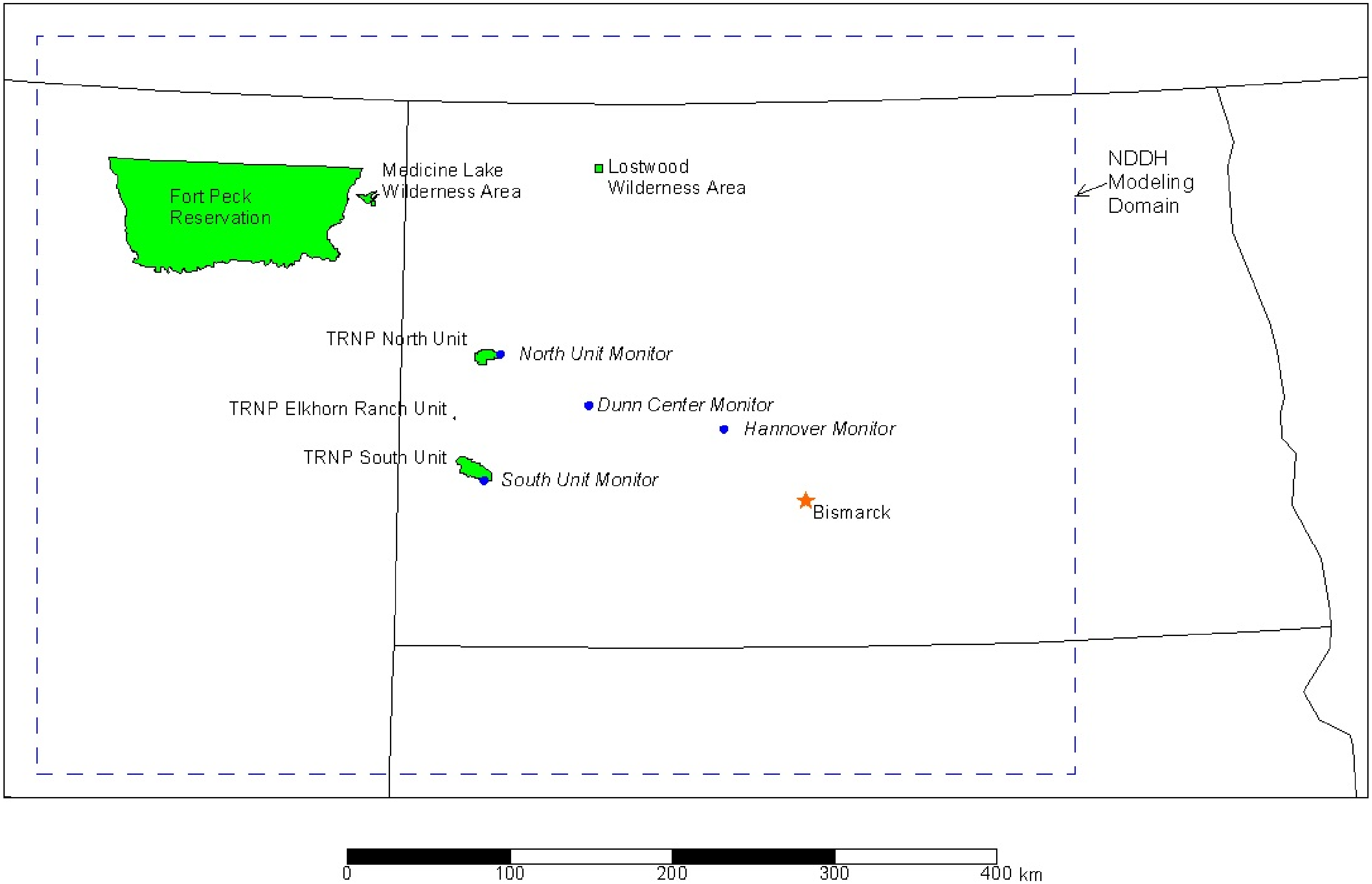


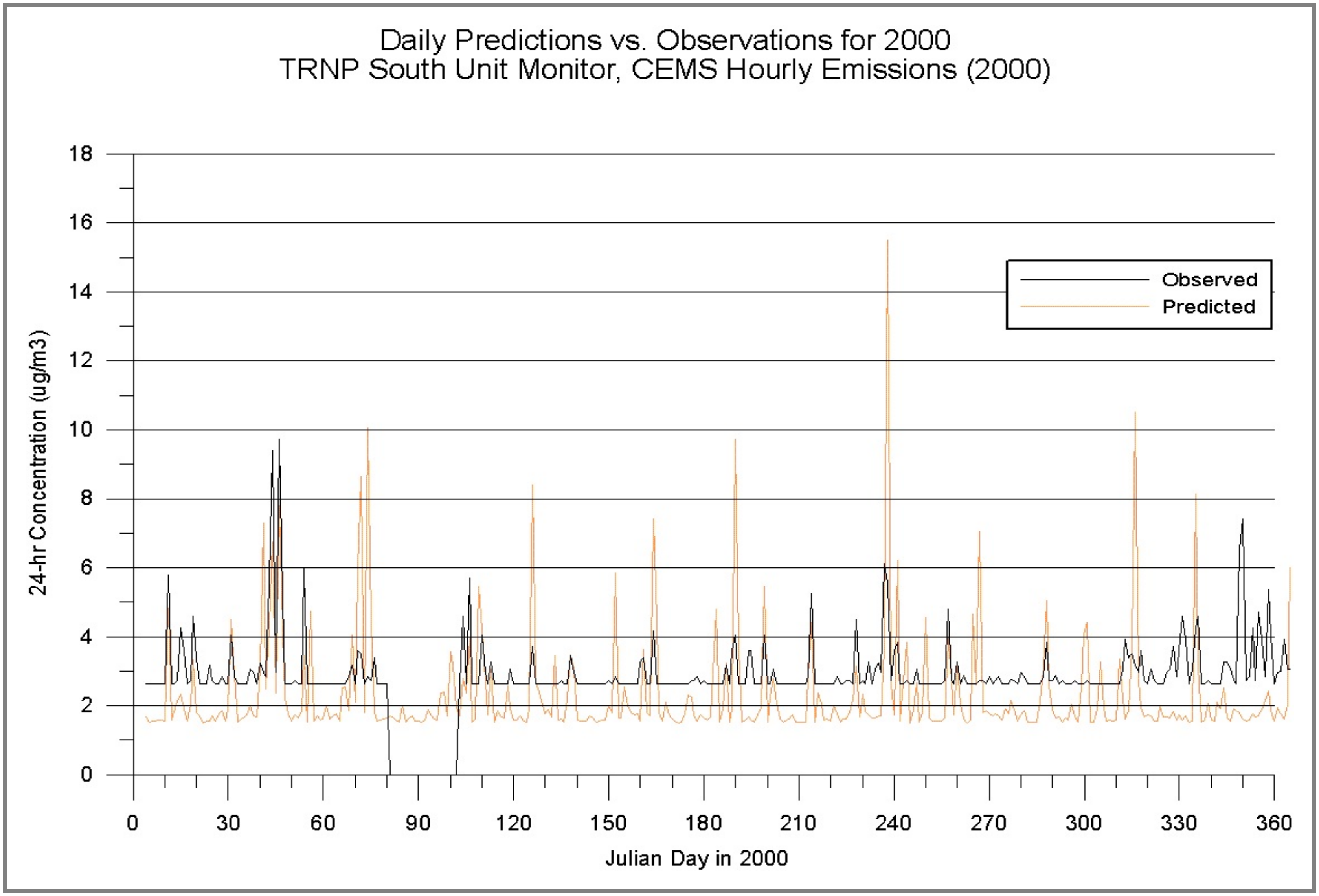
Table of 24-hour averaged sulfur dioxide concentrations at four monitoring locations for years 2000, 2001 and 2002.

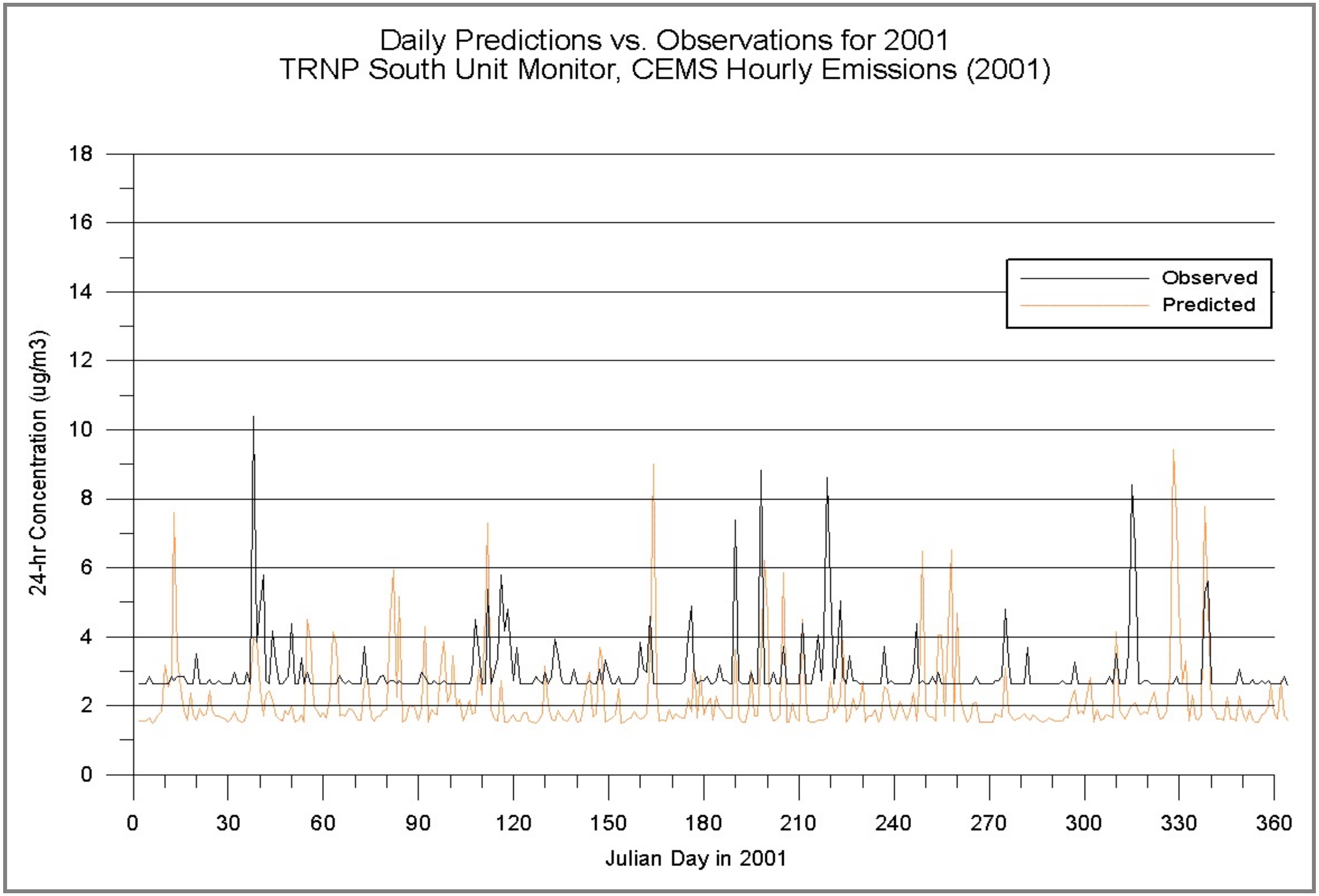
Year 2000	PSD Class I areas						PSD Class II area					
	TRNP-NU			TRNP-SU			Dunn Center			Hannover		
	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3
1				11	2.21	5.79	2	2.13	5.57	31	11.58	30.35
2				15	1.63	4.26	5	2.21	5.79	41	5.50	14.41
3				16	1.38	3.60	11	4.00	10.48	42	4.71	12.34
4				19	1.75	4.59	12	2.64	6.91	43	6.33	16.59
5				31	1.54	4.04	15	2.42	6.33	49	4.08	10.70
6			no	43	2.13	5.57	19	1.96	5.13	61	4.64	12.15
7				44	3.58	9.39	31	3.38	8.84	66	4.50	11.79
8			data	46	3.71	9.72	40	2.41	6.31	67	4.79	12.55
9				47	1.96	5.13	43	4.54	11.90	69	6.92	18.12
10			for	54	2.27	5.95	44	2.13	5.57	71	11.17	29.26
11				71	1.38	3.60	45	2.96	7.75	97	4.71	12.34
12			year	104	1.75	4.59	46	2.17	5.68	104	6.08	15.94
13				106	2.17	5.68	47	2.21	5.79	105	4.08	10.70
14			2000	110	1.54	4.04	49	1.92	5.02	119	4.63	12.12
15				126	1.42	3.71	65	3.88	10.15	147	6.13	16.05
16				164	1.58	4.15	69	2.21	5.79	161	5.38	14.08
17				189	1.38	3.60	74	2.04	5.35	163	4.13	10.81
18				190	1.54	4.04	76	3.21	8.41	171	4.58	12.01
19				199	1.54	4.04	106	3.42	8.95	187	5.88	15.39
20				214	2.00	5.24	152	2.38	6.22	194	7.04	18.45
21				228	1.71	4.48	184	3.71	9.72	195	7.96	20.85
22				237	2.33	6.11	187	2.05	5.36	196	4.38	11.46
23				238	2.13	5.57	199	1.96	5.13	201	4.09	10.72
24				241	1.46	3.82	214	3.04	7.97	202	5.04	13.21
25				257	1.83	4.80	228	2.38	6.22	208	10.50	27.51
26				288	1.46	3.82	238	6.17	16.16	217	7.29	19.10
27				313	1.50	3.93	244	2.88	7.53	220	4.46	11.68
28				328	1.42	3.71	247	3.17	8.30	222	5.29	13.86
29				331	1.75	4.59	320	2.09	5.48	228	7.64	20.01
30				332	1.50	3.93	345	2.29	6.00	234	10.21	26.75
31				335	1.63	4.26	348	7.54	19.76	237	6.08	15.94
32				336	1.75	4.59	349	3.88	10.15	257	4.55	11.91
33				349	2.50	6.55	350	7.75	20.31	260	8.29	21.72
34				350	2.83	7.42	351	2.04	5.35	301	4.46	11.68
35				353	1.63	4.26	356	2.00	5.24	334	4.46	11.68
36				355	1.79	4.69	358	3.29	8.62	340	4.25	11.14
37				356	1.50	3.93	359	2.71	7.10	346	4.58	12.01
38				358	2.04	5.35	360	2.08	5.46	350	5.29	13.86
39				359	1.54	4.04	363	2.38	6.22	351	4.33	11.35
40				363	1.50	3.93	366	1.96	5.13	366	4.42	11.57

Year 2001	PSD Class I areas						PSD Class II area					
	TRNP-NU			TRNP-SU			Dunn Center			Hannover		
	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3
1	237	1.13	2.95	20	1.33	3.49	2	2.08	5.46	10	4.83	12.66
2	239	1.08	2.84	38	3.96	10.37	11	2.13	5.57	12	4.21	11.03
3	243	1.23	3.22	39	1.46	3.82	15	2.21	5.79	13	7.17	18.78
4	246	1.33	3.49	40	1.88	4.91	20	1.75	4.59	24	15.96	41.81
5	249	1.13	2.95	41	2.21	5.79	24	1.78	4.67	41	5.63	14.74
6	254	1.04	2.73	44	1.58	4.15	31	2.17	5.68	42	3.42	8.95
7	255	1.04	2.73	50	1.67	4.37	32	2.46	6.44	57	3.46	9.06
8	256	1.08	2.84	73	1.42	3.71	38	2.25	5.90	62	3.42	8.95
9	258	1.38	3.60	108	1.71	4.48	39	1.75	4.59	63	4.75	12.45
10	261	1.05	2.74	109	1.38	3.60	41	2.33	6.11	67	3.25	8.52
11	265	1.08	2.84	112	2.04	5.35	42	3.21	8.41	73	4.13	10.81
12	266	1.13	2.95	116	2.21	5.79	43	2.17	5.68	74	3.17	8.30
13	272	1.21	3.17	117	1.58	4.15	44	3.17	8.30	75	3.88	10.15
14	274	1.92	5.02	118	1.83	4.80	45	5.21	13.65	81	5.58	14.63
15	275	1.19	3.12	119	1.50	3.93	46	2.04	5.35	84	9.79	25.65
16	288	1.08	2.84	121	1.41	3.69	48	1.75	4.59	87	5.00	13.10
17	297	1.38	3.60	133	1.50	3.93	49	1.96	5.13	91	6.79	17.79
18	298	1.17	3.06	160	1.46	3.82	50	2.54	6.66	93	3.71	9.72
19	299	1.04	2.73	163	1.75	4.59	55	2.21	5.79	97	4.08	10.70
20	310	1.54	4.04	175	1.54	4.04	56	3.21	8.41	111	4.38	11.46
21	314	1.21	3.17	176	1.86	4.88	57	3.75	9.83	112	5.00	13.10
22	316	1.04	2.73	190	2.82	7.38	58	3.21	8.41	116	9.17	24.02
23	328	1.42	3.71	198	3.36	8.81	64	2.25	5.90	123	4.17	10.92
24	331	1.04	2.73	205	1.42	3.71	109	2.50	6.55	139	3.50	9.17
25	332	1.14	2.99	211	1.67	4.37	112	2.13	5.57	144	3.73	9.77
26	334	1.04	2.73	216	1.54	4.04	148	1.92	5.02	145	6.88	18.01
27	340	1.04	2.73	218	1.50	3.93	177	2.75	7.21	149	4.50	11.79
28	341	1.17	3.06	219	3.29	8.62	178	3.08	8.08	150	3.79	9.93
29	345	2.38	6.24	220	2.08	5.46	190	4.77	12.50	154	5.17	13.54
30	346	1.58	4.15	222	1.33	3.49	195	2.96	7.75	155	3.38	8.84
31	348	1.04	2.73	223	1.92	5.02	205	3.08	8.08	159	4.63	12.12
32	350	1.08	2.84	237	1.42	3.71	219	1.83	4.80	167	3.17	8.30
33	355	1.08	2.84	247	1.67	4.37	220	2.58	6.77	315	3.25	8.52
34	357	1.08	2.84	275	1.83	4.80	224	1.92	5.02	316	5.25	13.76
35	358	1.04	2.73	282	1.41	3.69	247	2.17	5.68	327	4.54	11.90
36	360	1.16	3.03	310	1.33	3.49	258	2.96	7.75	330	4.54	11.90
37	361	1.63	4.26	315	3.21	8.41	260	1.75	4.59	333	5.38	14.08
38	362	1.71	4.48	316	2.50	6.55	310	2.25	5.90	338	4.86	12.74
39	364	1.50	3.93	338	2.00	5.24	345	1.83	4.80	340	3.38	8.84
40	365	1.25	3.28	339	2.14	5.60	346	1.96	5.13	359	3.21	8.41

Year 2002	PSD Class I areas						PSD Class II area					
	TRNP-NU			TRNP-SU			Dunn Center			Hannover		
	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3	J. Date	ppb	ug/m3
1	5	1.42	3.71	26	2.63	6.88	26	3.46	9.06	22	6.21	16.27
2	11	1.29	3.38	27	1.50	3.93	27	2.00	5.24	23	4.88	12.77
3	17	1.33	3.49	28	3.04	7.97	28	3.10	8.11	26	3.63	9.50
4	18	1.5	3.93	29	2.46	6.44	39	1.79	4.69	39	5.21	13.65
5	28	1.29	3.38	49	2.38	6.22	65	1.71	4.48	49	7.00	18.34
6	29	1.67	4.37	64	2.25	5.90	66	2.79	7.31	51	7.92	20.74
7	39	1.92	5.02	66	1.75	4.59	68	1.71	4.48	52	3.83	10.04
8	61	1.29	3.38	67	1.54	4.04	69	2.17	5.68	70	8.19	21.46
9	66	2.88	7.53	78	1.92	5.02	73	2.13	5.57	72	5.42	14.19
10	69	1.63	4.26	80	1.67	4.37	75	1.71	4.48	78	3.17	8.30
11	70	1.33	3.49	82	1.67	4.37	78	1.63	4.26	79	3.71	9.72
12	73	3.42	8.95	141	2.79	7.31	80	2.00	5.24	81	7.54	19.76
13	74	1.42	3.71	173	2.00	5.24	81	1.58	4.15	82	5.92	15.50
14	75	1.29	3.38	234	1.83	4.80	83	2.46	6.44	95	4.96	12.99
15	77	1.5	3.93	235	2.21	5.79	95	2.79	7.31	97	3.71	9.72
16	78	1.82	4.76	236	2.08	5.46	100	1.75	4.59	105	4.54	11.90
17	79	1.58	4.15	237	2.00	5.24	116	1.71	4.48	124	3.21	8.41
18	80	2.25	5.90	238	2.04	5.35	122	1.54	4.04	126	3.25	8.52
19	81	1.33	3.49	239	1.96	5.13	127	1.50	3.93	136	5.25	13.76
20	83	2.42	6.33	240	2.00	5.24	137	1.67	4.37	137	5.17	13.54
21	92	1.67	4.37	241	2.17	5.68	139	1.63	4.26	152	3.46	9.06
22	95	1.92	5.02	242	1.96	5.13	152	1.50	3.93	158	4.63	12.12
23	116	1.58	4.15	243	2.08	5.46	153	2.45	6.43	160	5.87	15.38
24	122	1.38	3.60	244	2.08	5.46	173	2.50	6.55	182	3.67	9.61
25	138	1.33	3.49	246	1.79	4.69	174	1.88	4.91	184	3.21	8.41
26	139	1.33	3.49	247	2.38	6.22	184	2.25	5.90	188	3.33	8.73
27	149	1.52	3.99	248	4.75	12.45	187	2.96	7.75	199	4.71	12.34
28	153	1.54	4.04	249	2.08	5.46	189	1.83	4.80	204	4.50	11.79
29	184	1.29	3.38	250	2.08	5.46	198	2.33	6.11	205	14.13	37.01
30	187	1.29	3.38	251	1.96	5.13	199	1.50	3.93	206	3.38	8.84
31	216	1.46	3.83	252	1.83	4.80	216	1.67	4.37	210	3.38	8.84
32	293	1.63	4.26	253	1.71	4.48	234	2.29	6.00	211	9.88	25.87
33	294	1.5	3.93	255	1.83	4.80	247	1.50	3.93	230	6.79	17.79
34	302	1.64	4.29	283	2.67	6.99	248	1.67	4.37	295	3.46	9.06
35	336	1.38	3.60	289	1.75	4.59	293	3.42	8.95	296	3.67	9.61
36	337	1.63	4.26	290	1.75	4.59	294	1.96	5.13	300	3.54	9.28
37	339	1.54	4.04	292	2.17	5.68	301	1.58	4.15	310	3.67	9.61
38	353	1.38	3.6	293	1.54	4.04	319	1.54	4.04	312	3.92	10.26
39	357	1.38	3.6	296	1.95	5.12	336	1.71	4.48	358	4.00	10.48
40	363	1.46	3.82	297	3.17	8.30	338	1.58	4.15	365	3.21	8.41

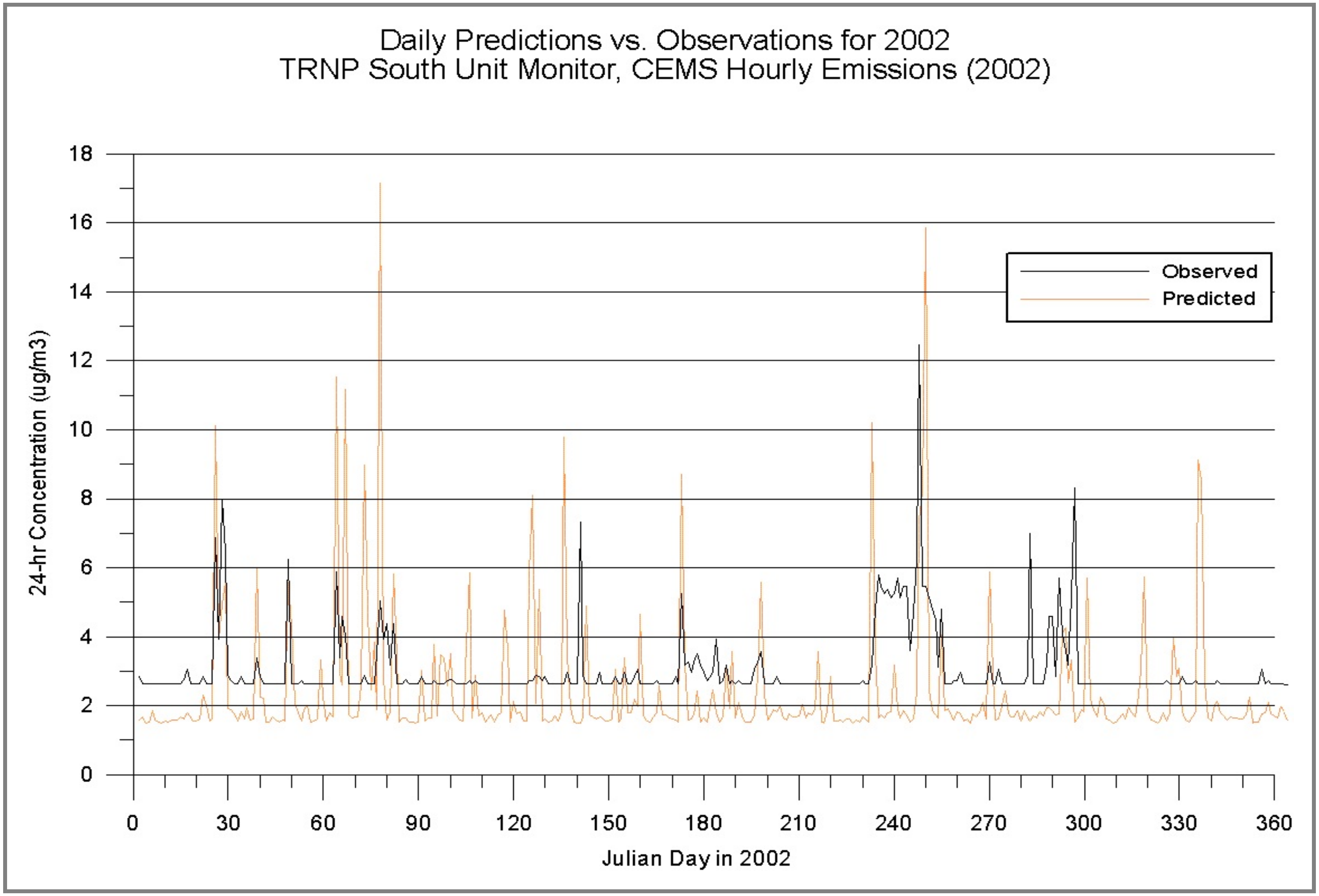
APPENDIX C. Time series plots of observed and predicted concentrations.



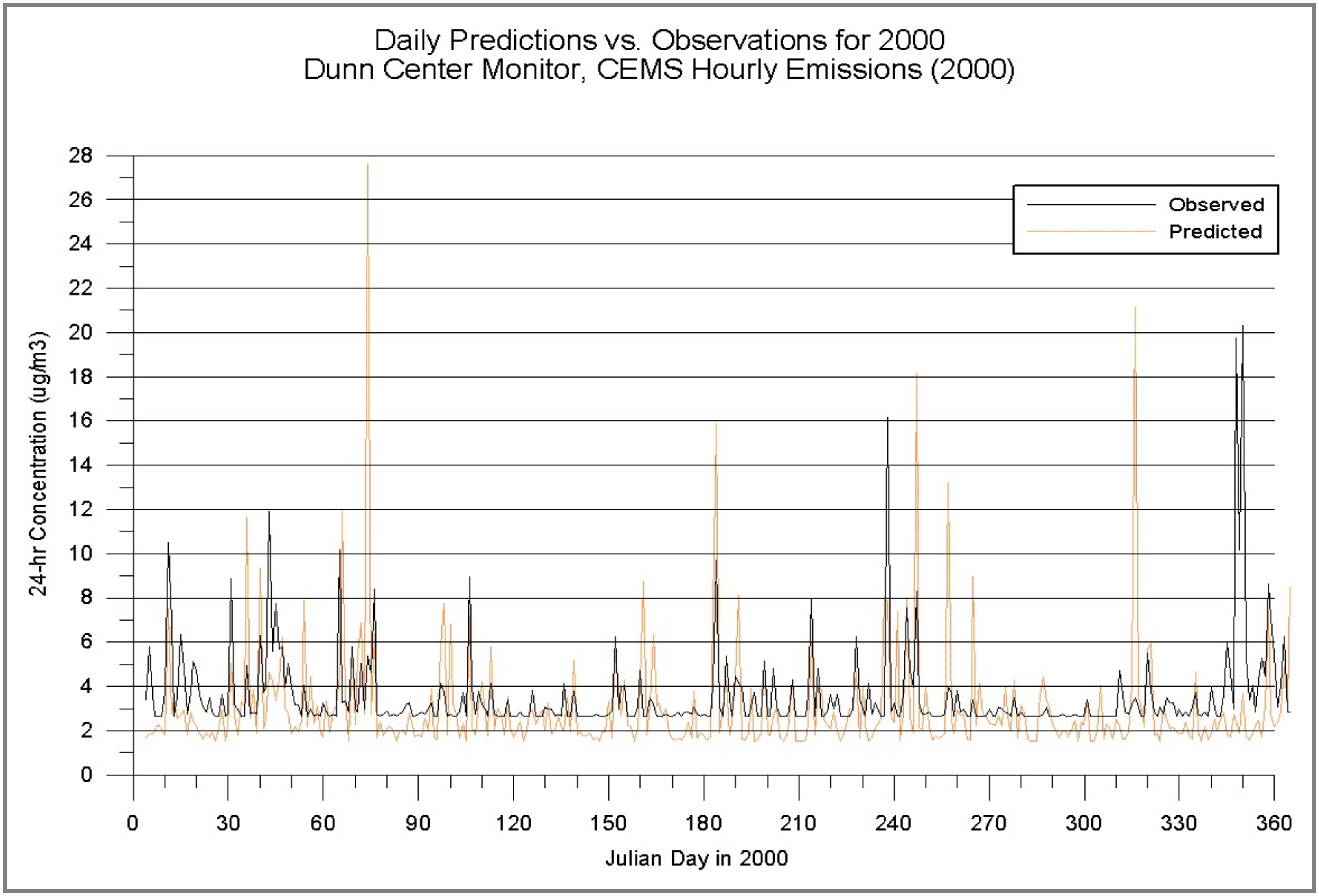


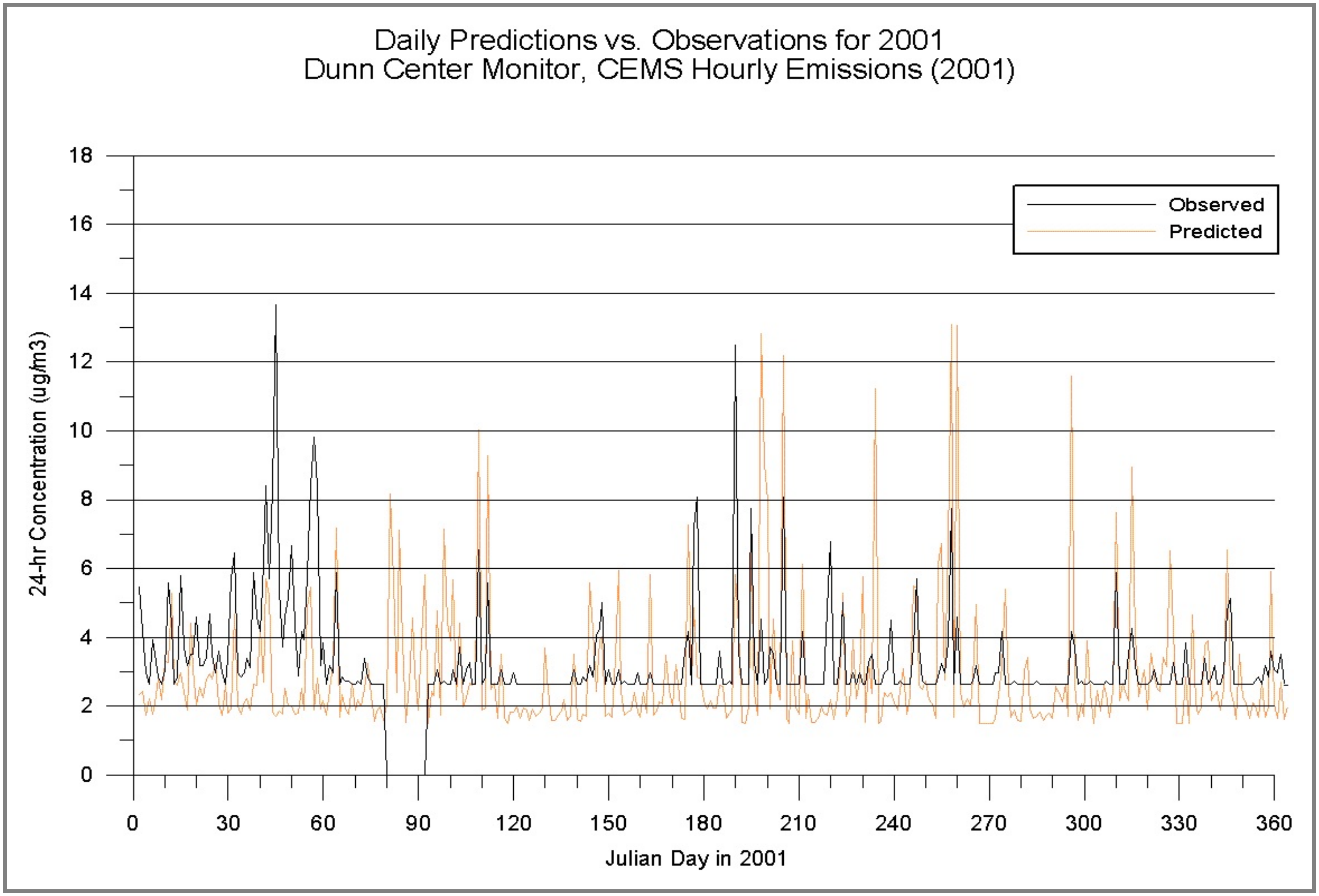
Daily Predictions vs. Observations for 2001
TRNP South Unit Monitor, CEMS Hourly Emissions (2001)
24-hr Concentration (ug/m3)
0
2
4
6
8
10
12
14
16
18
0
30
60
90
120
150
180
210
240
270
300
330
360
Julian Day in 2001
Observed
Predicted

Final.

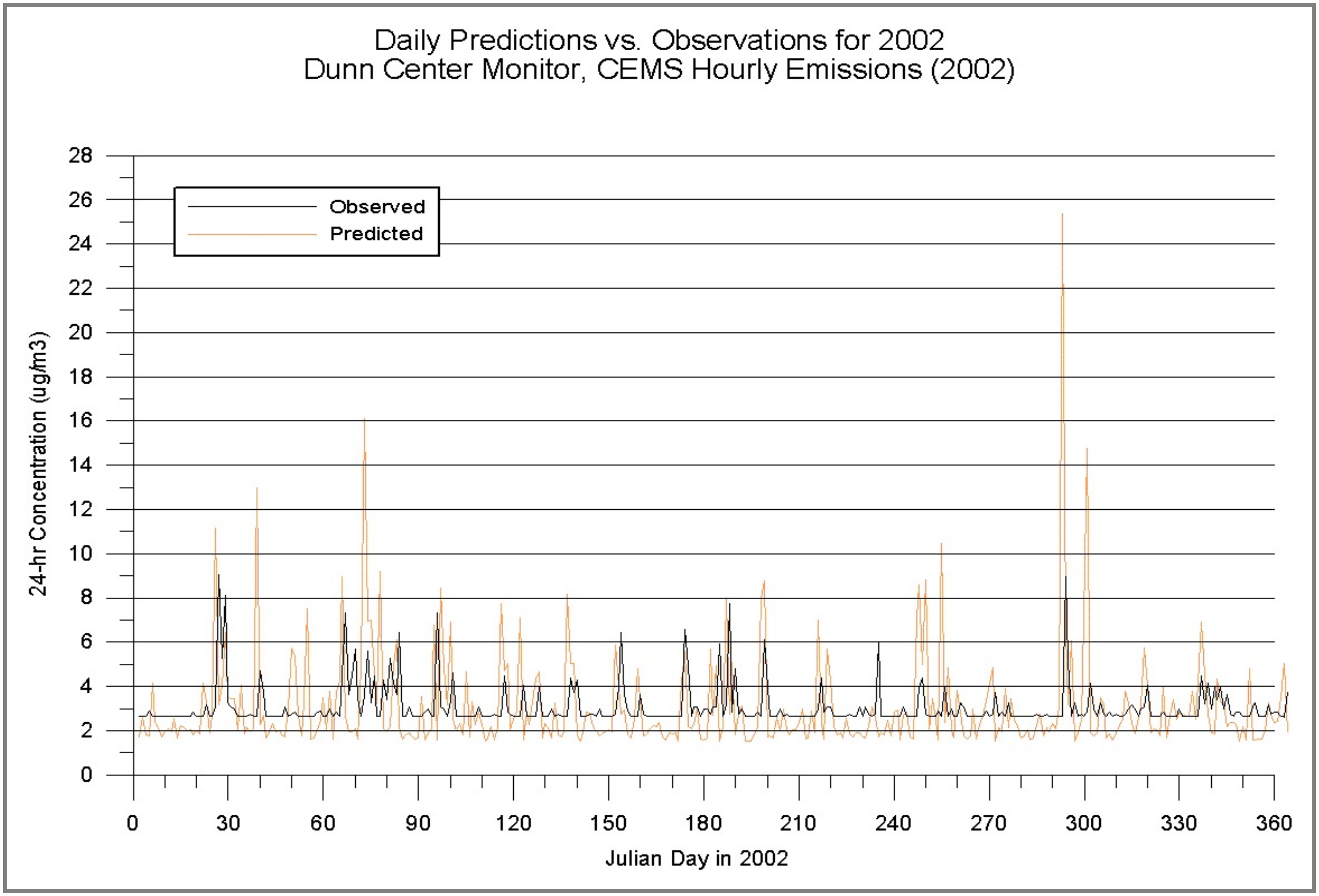


Daily Predictions vs. Observations for 2002
TRNP South Unit Monitor, CEMS Hourly Emissions (2002)
24-hr Concentration (ug/m3)
0
2
4
6
8
10
12
14
16
18
0
30
60
90
120
150
180
210
240
270
300
330
360
Julian Day in 2002
Observed
Predicted


Daily Predictions vs. Observations for 2000
Dunn Center Monitor, CEMS Hourly Emissions (2000)
Observed
Predicted
24-hr Concentration (ug/m3)
Julian Day in 2000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
0
30
60
90
120
150
180
210
240
270
300
330
360



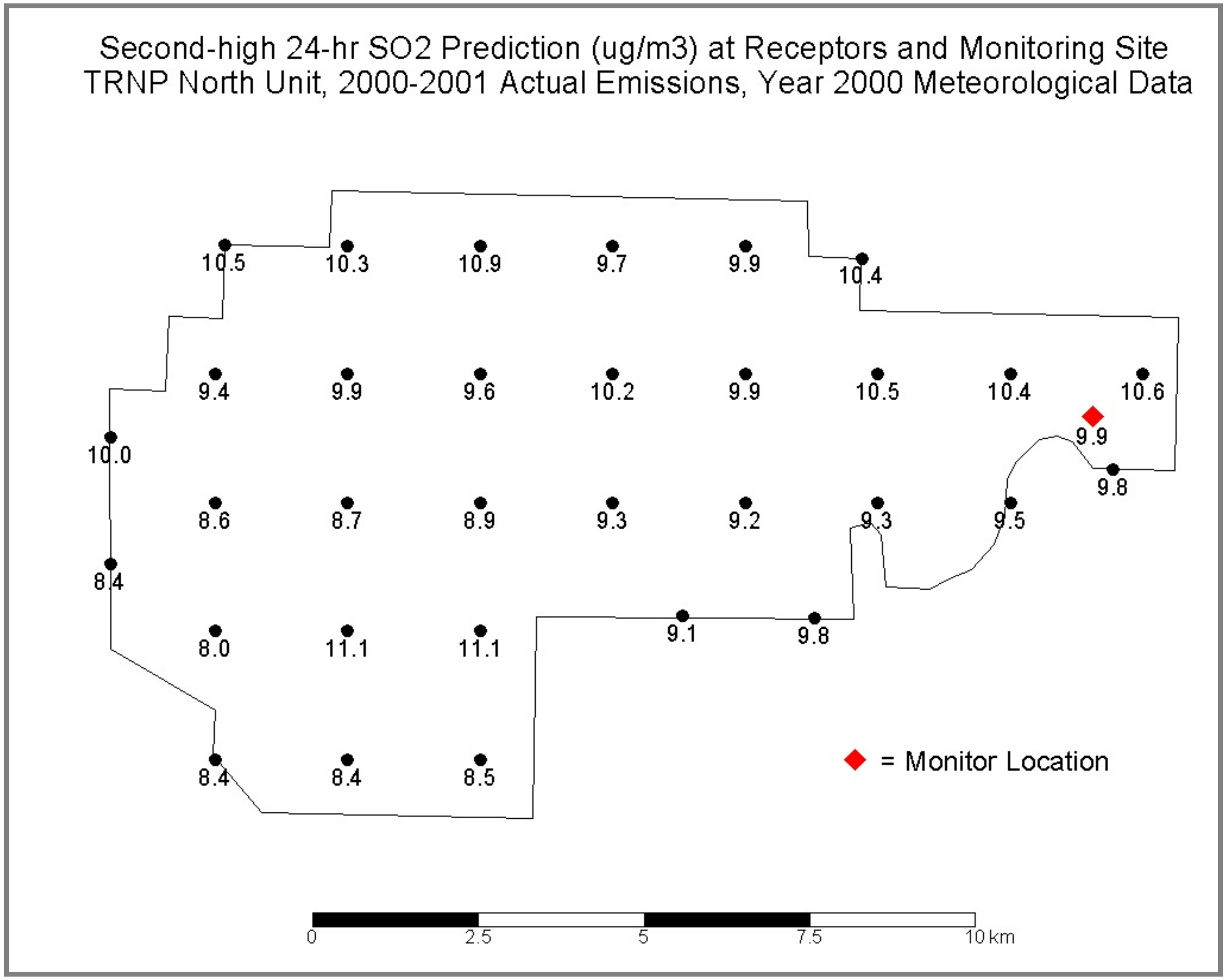
Daily Predictions vs. Observations for 2001
Dunn Center Monitor, CEMS Hourly Emissions (2001)
24-hr Concentration (ug/m3)
Julian Day in 2001
Observed
Predicted
0
2
4
6
8
10
12
14
16
18
0
30
60
90
120
150
180
210
240
270
300
330
360

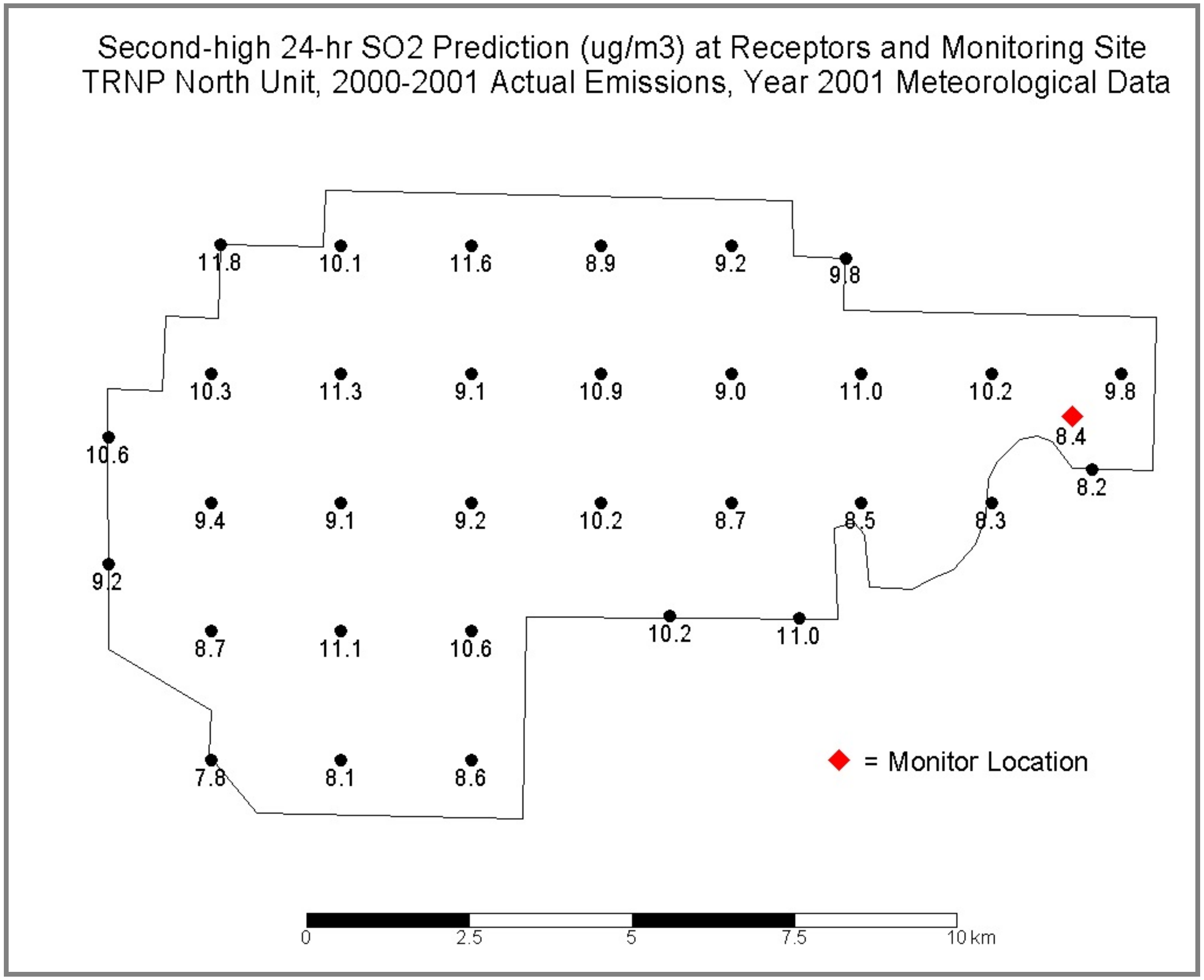

Daily Predictions vs. Observations for 2002
Dunn Center Monitor, CEMS Hourly Emissions (2002)
Observed
Predicted
24-hr Concentration (ug/m3)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
0
30
60
90
120
150
180
210
240
270
300
330
360
Julian Day in 2002

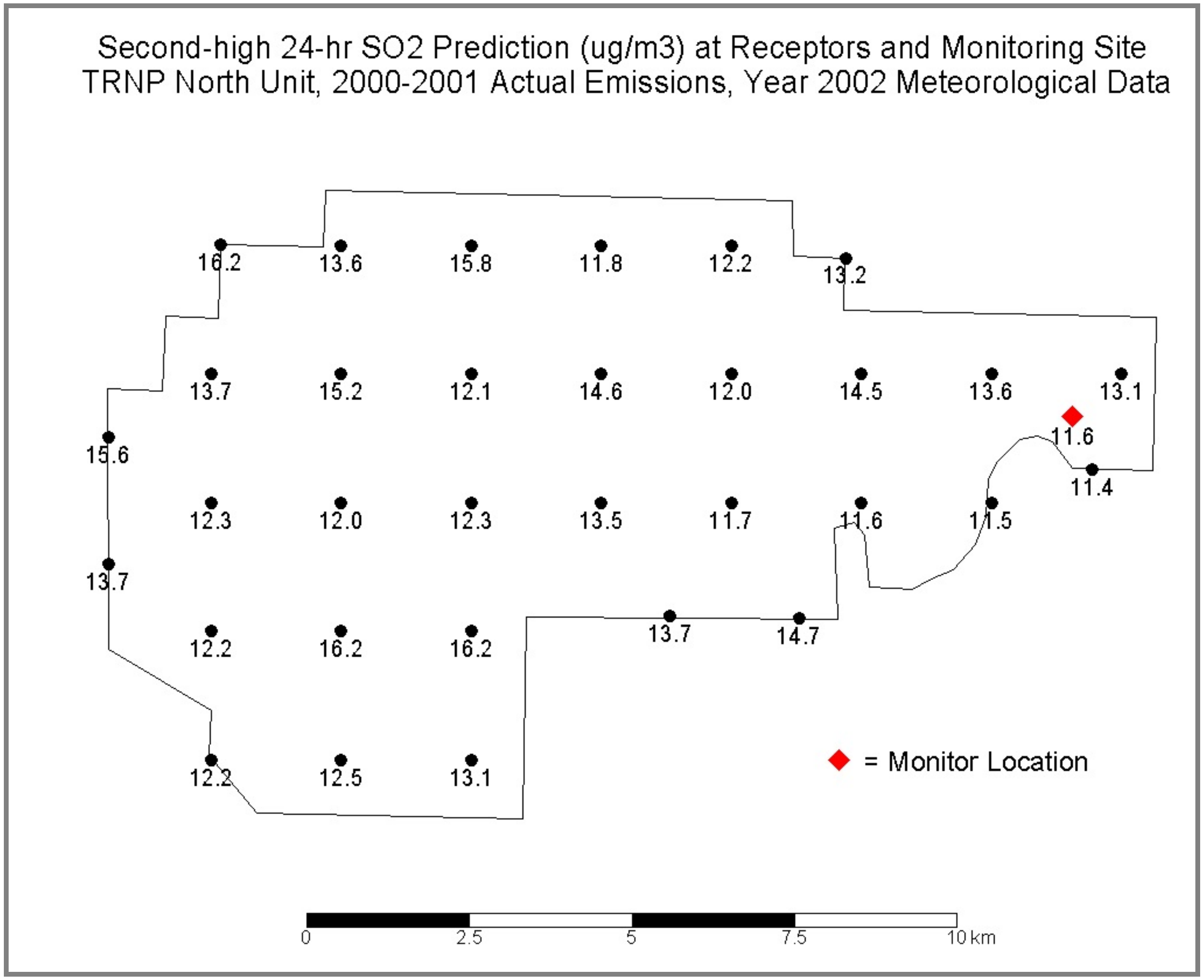
Final.

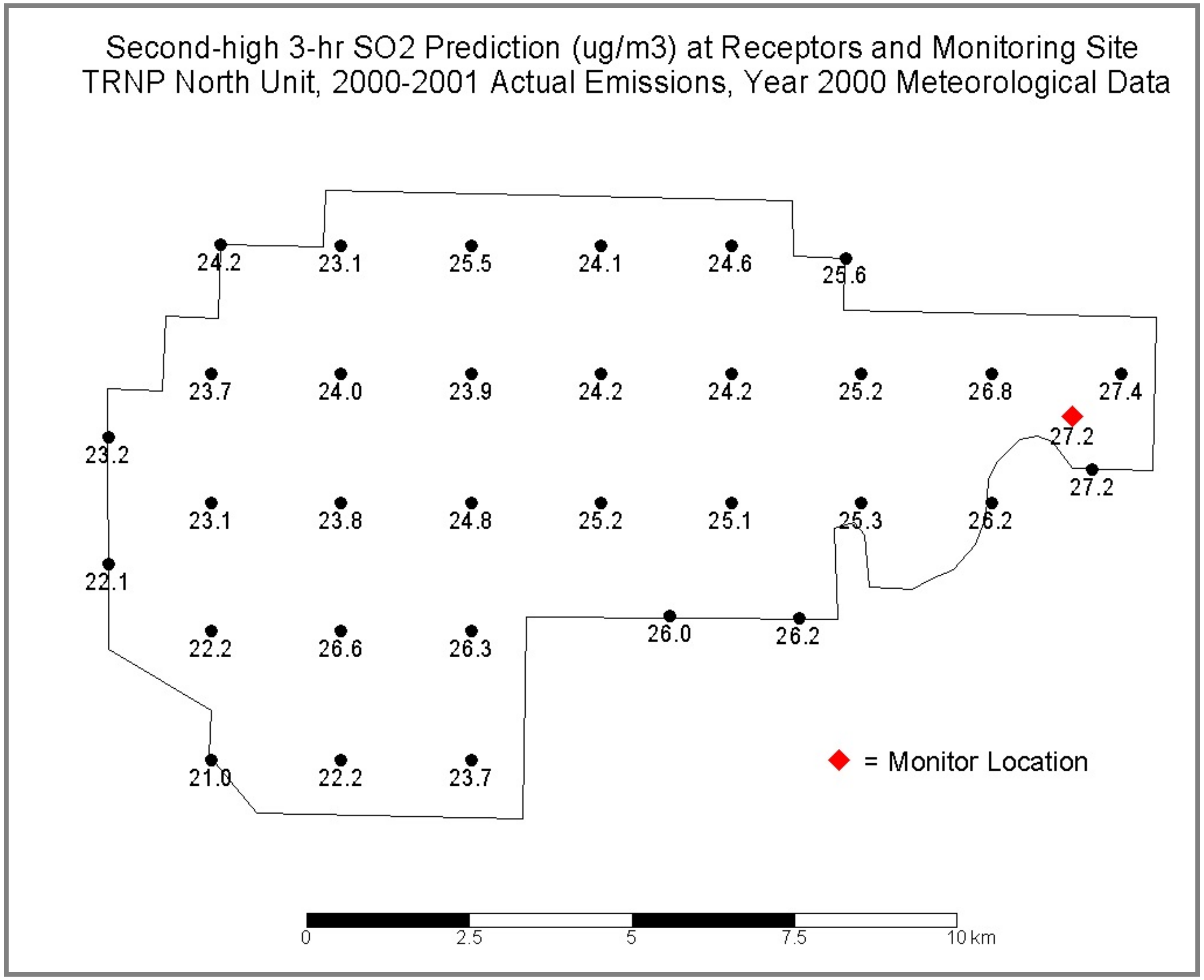
APPENDIX D. Maps of second highest predicted concentrations at receptors.

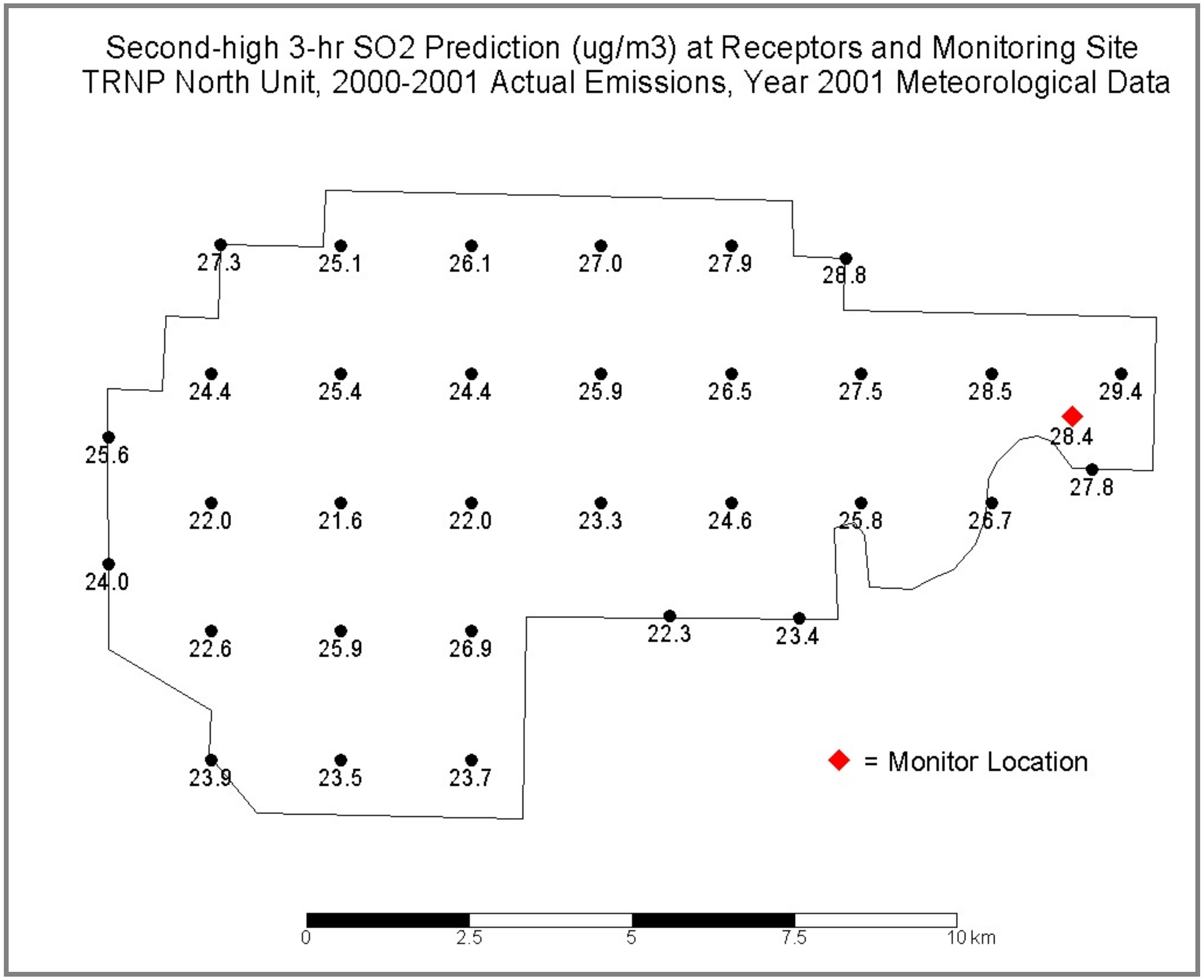
The plotted model predicted concentrations shown in the maps in this appendix do not include a background concentration.

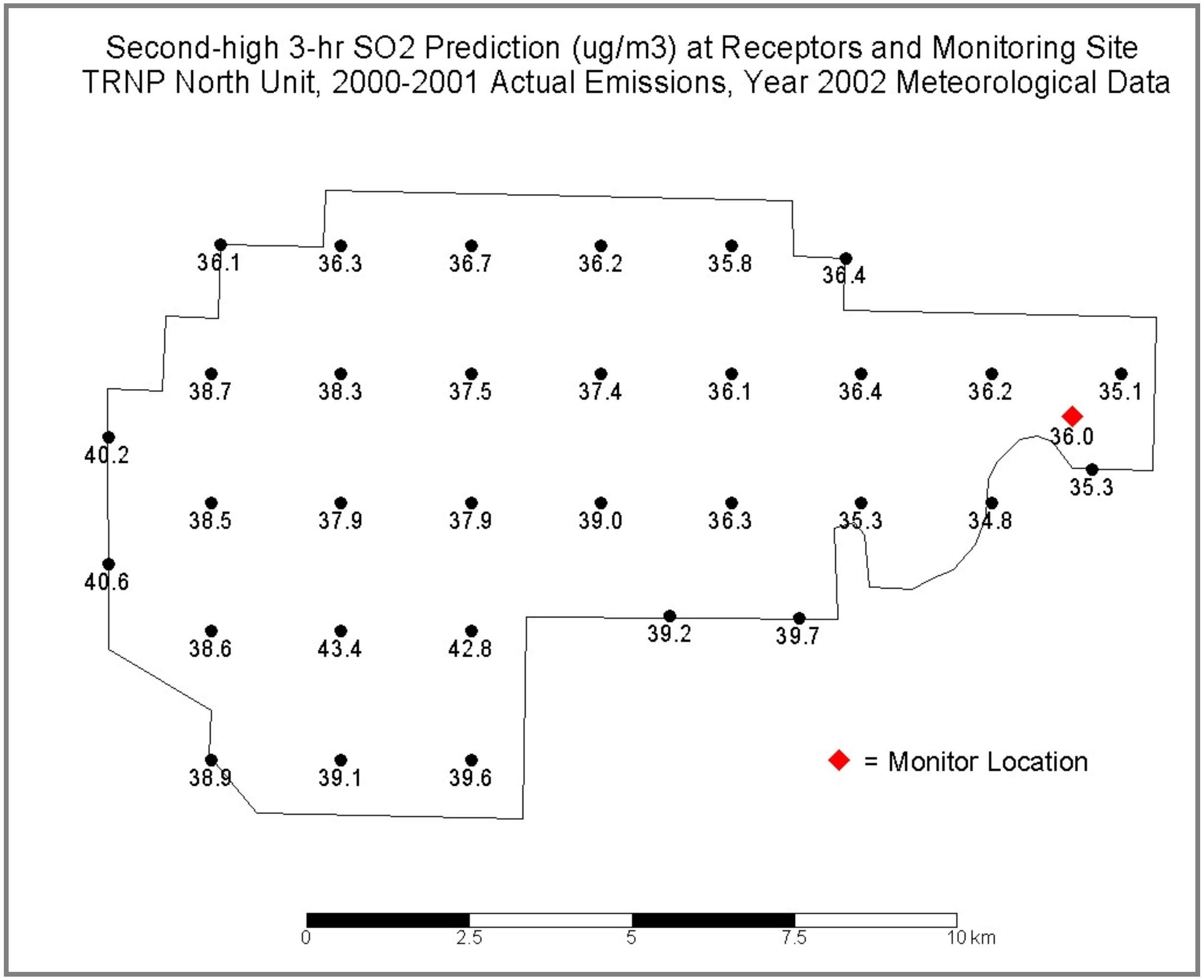


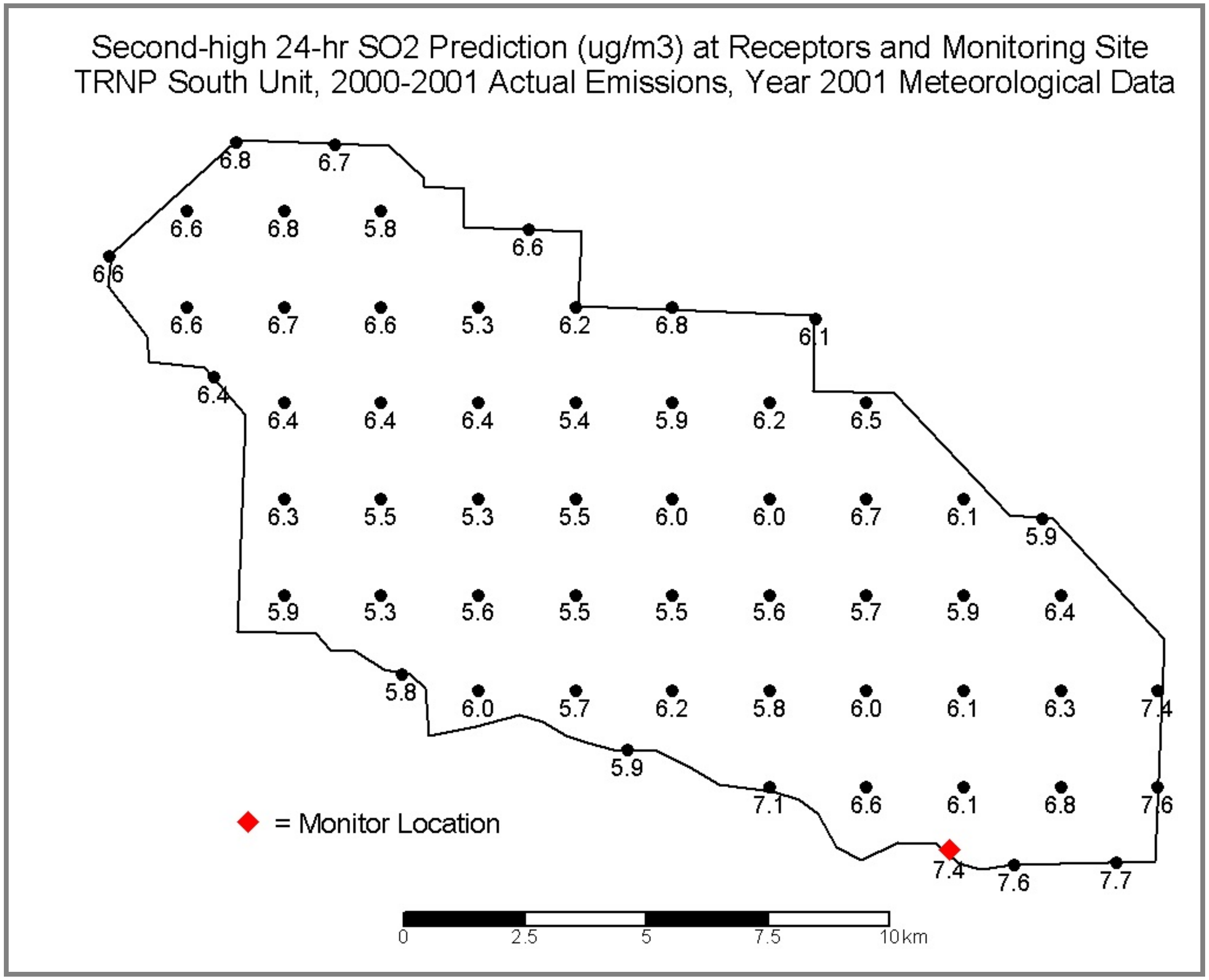

Second-high 24-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP North Unit, 2000-2001 Actual Emissions, Year 2001 Meteorological Data
11.8
10.1
11.6
8.9
9.2
9.8
10.3
11.3
9.1
10.9
9.0
11.0
10.2
9.8
8.4
10.6
8.2
9.4
9.1
9.2
10.2
8.7
8.5
8.3
9.2
8.7
11.1
10.6
10.2
11.0
7.8
8.1
8.6
= Monitor Location
0
2.5
5
7.5
10 km

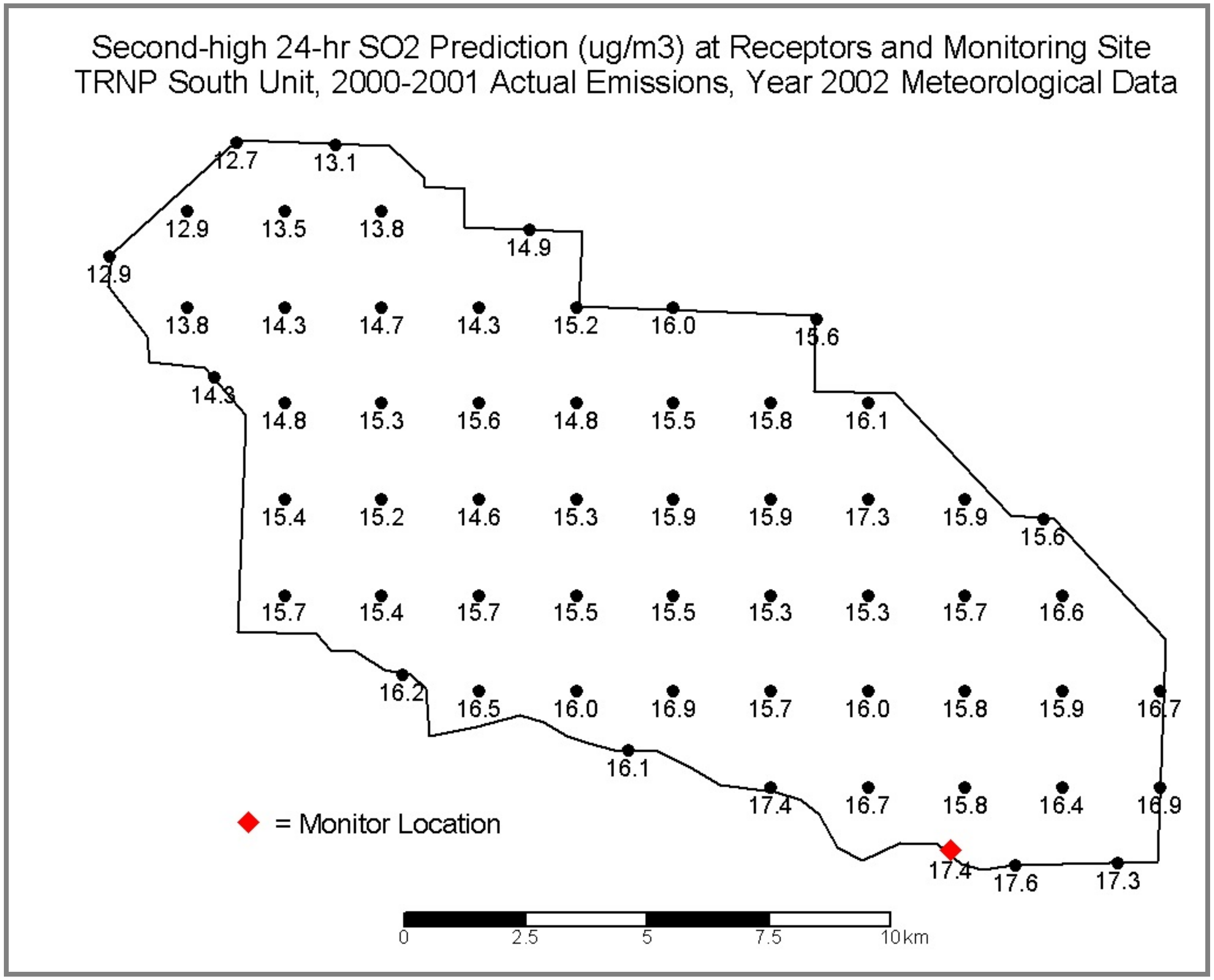

Second-high 24-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP North Unit, 2000-2001 Actual Emissions, Year 2002 Meteorological Data
16.2
13.6
15.8
11.8
12.2
13.2
13.7
15.2
12.1
14.6
12.0
14.5
13.6
13.1
11.6
15.6
11.4
12.3
12.0
12.3
13.5
11.7
11.6
11.5
13.7
13.7
14.7
12.2
16.2
16.2
= Monitor Location
12.2
12.5
13.1
0
2.5
5
7.5
10 km

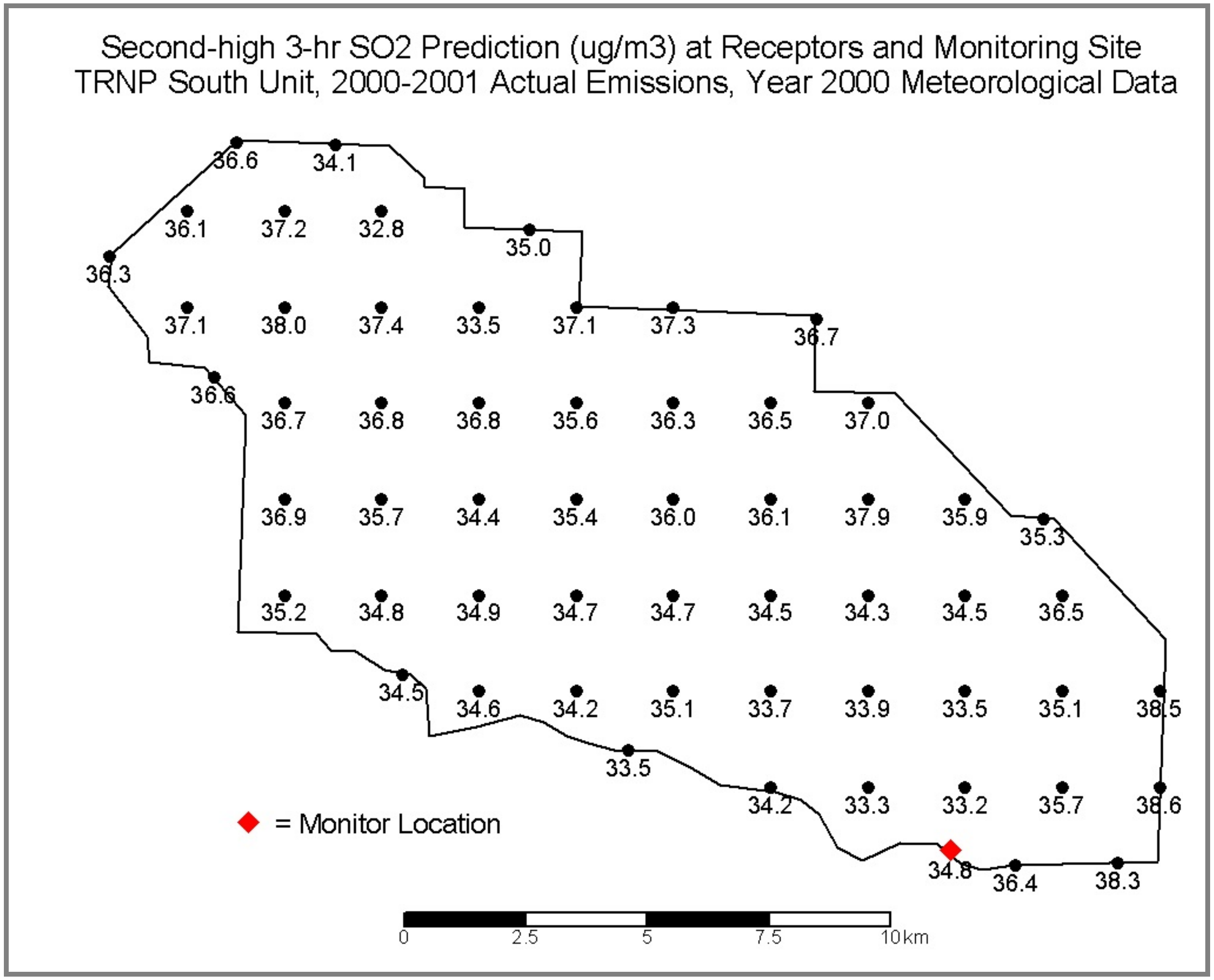

Second-high 3-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP North Unit, 2000-2001 Actual Emissions, Year 2000 Meteorological Data
24.2
23.1
25.5
24.1
24.6
25.6
23.7
24.0
23.9
24.2
24.2
25.2
26.8
27.4
27.2
23.2
27.2
23.1
23.8
24.8
25.2
25.1
25.3
26.2
22.1
26.0
26.2
22.2
26.6
26.3
= Monitor Location
21.0
22.2
23.7
0
2.5
5
7.5
10 km

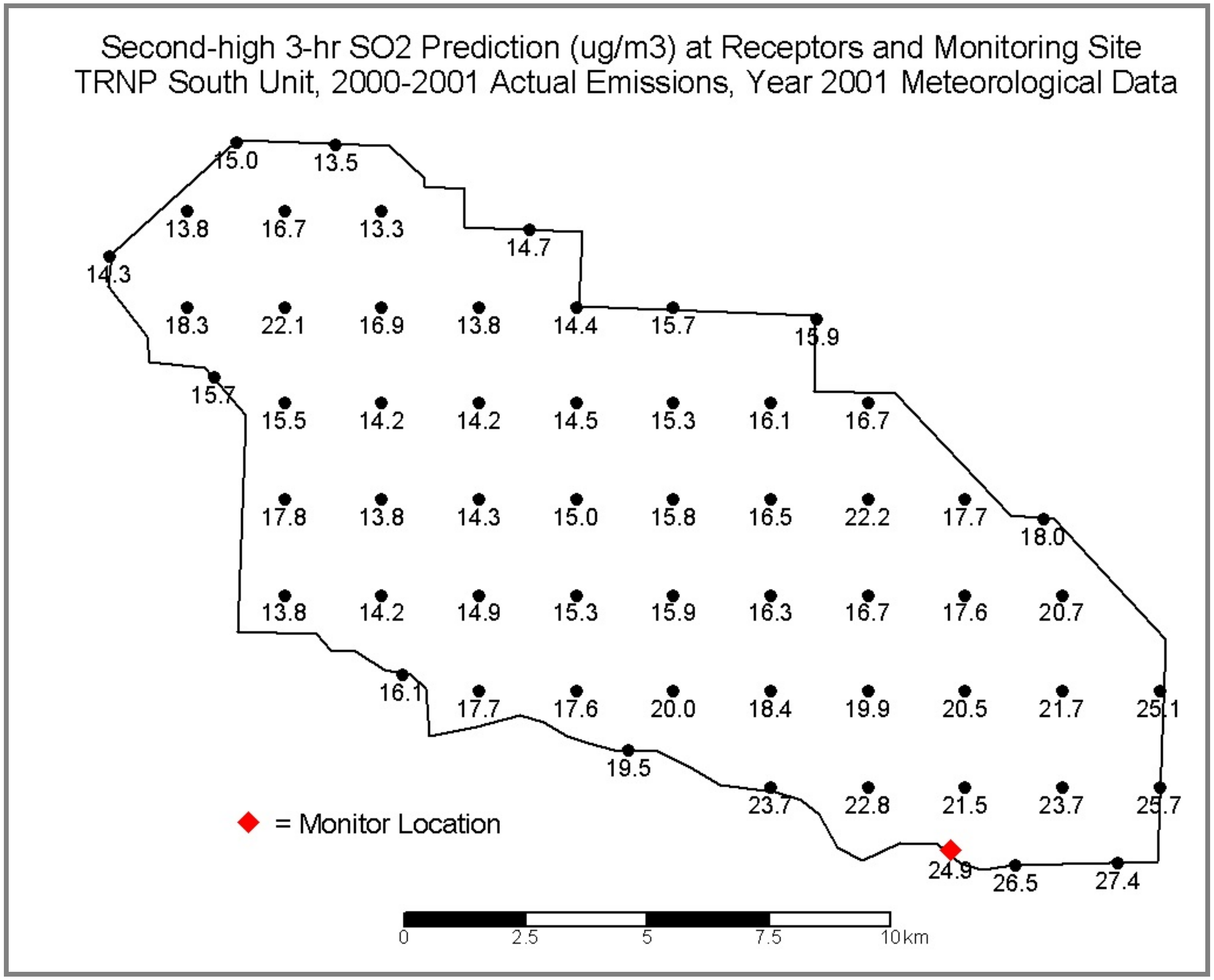

Second-high 3-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP North Unit, 2000-2001 Actual Emissions, Year 2001 Meteorological Data
27.3
25.1
26.1
27.0
27.9
28.8
24.4
25.4
24.4
25.9
26.5
27.5
28.5
29.4
28.4
25.6
27.8
22.0
21.6
22.0
23.3
24.6
25.8
26.7
24.0
22.3
23.4
22.6
25.9
26.9
23.9
23.5
23.7
= Monitor Location
0
2.5
5
7.5
10 km

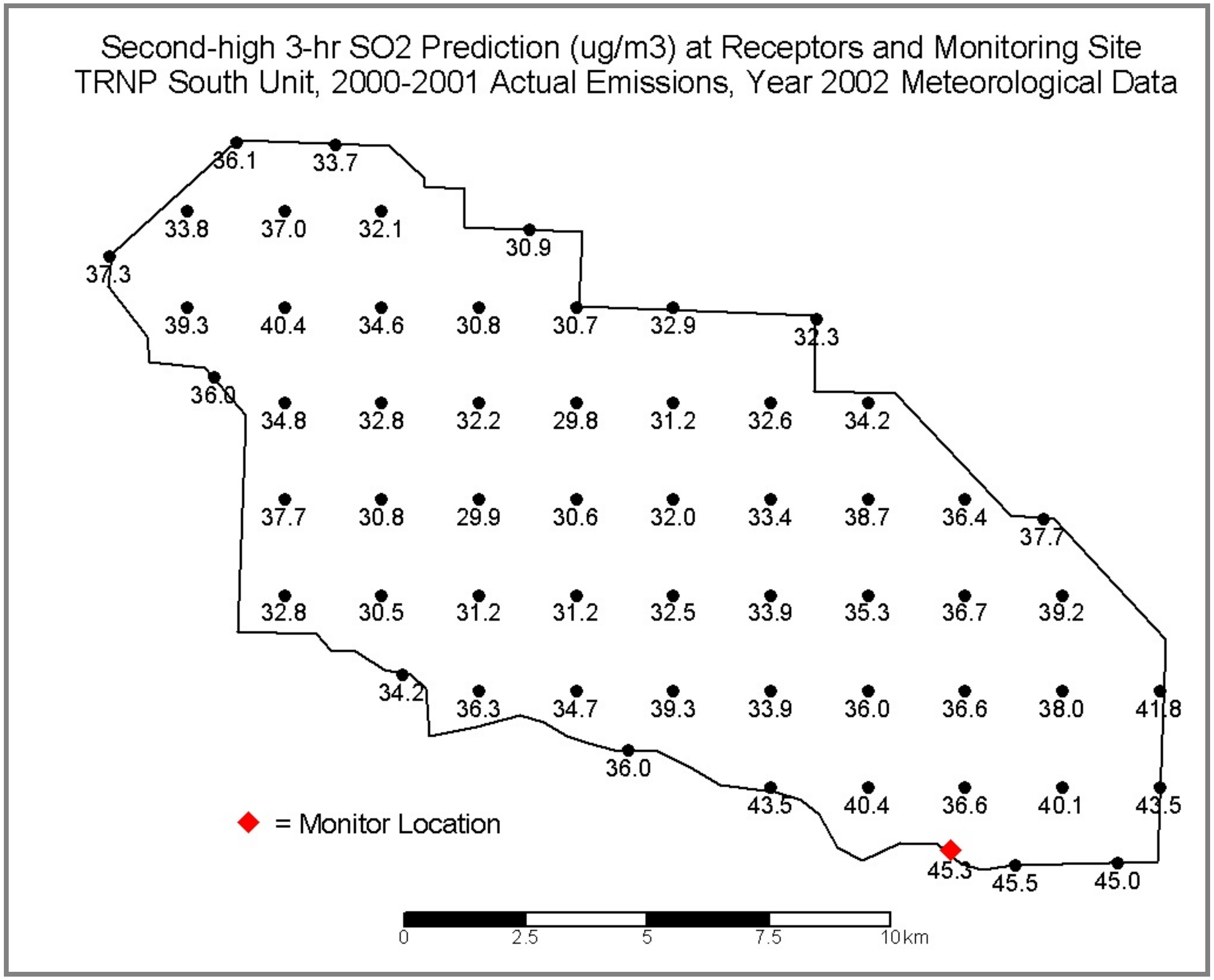

Second-high 3-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP North Unit, 2000-2001 Actual Emissions, Year 2002 Meteorological Data
36.1
36.3
36.7
36.2
35.8
36.4
38.7
38.3
37.5
37.4
36.1
36.4
36.2
35.1
36.0
40.2
35.3
38.5
37.9
37.9
39.0
36.3
35.3
34.8
40.6
38.6
43.4
42.8
39.2
39.7
38.9
39.1
39.6
= Monitor Location
0
2.5
5
7.5
10 km


Second-high 24-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP South Unit, 2000-2001 Actual Emissions, Year 2001 Meteorological Data
6.8
6.7
6.6
6.8
5.8
6.6
6.6
6.6
6.7
6.6
5.3
6.2
6.8
6.1
6.4
6.4
6.4
6.4
5.4
5.9
6.2
6.5
6.3
5.5
5.3
5.5
6.0
6.0
6.7
6.1
5.9
5.9
5.3
5.6
5.5
5.5
5.6
5.7
5.9
6.4
5.8
6.0
5.7
6.2
5.8
6.0
6.1
6.3
7.4
5.9
7.1
6.6
6.1
6.8
7.6
= Monitor Location
7.4
7.6
7.7
0
2.5
5
7.5
10km


Second-high 24-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP South Unit, 2000-2001 Actual Emissions, Year 2002 Meteorological Data
12.7
13.1
12.9
13.5
13.8
14.9
12.9
13.8
14.3
14.7
14.3
15.2
16.0
15.6
14.3
14.8
15.3
15.6
14.8
15.5
15.8
16.1
15.4
15.2
14.6
15.3
15.9
15.9
17.3
15.9
15.6
15.7
15.4
15.7
15.5
15.5
15.3
15.3
15.7
16.6
16.2
16.5
16.0
16.9
15.7
16.0
15.8
15.9
16.7
16.1
17.4
16.7
15.8
16.4
16.9
= Monitor Location
17.4
17.6
17.3
0
2.5
5
7.5
10km

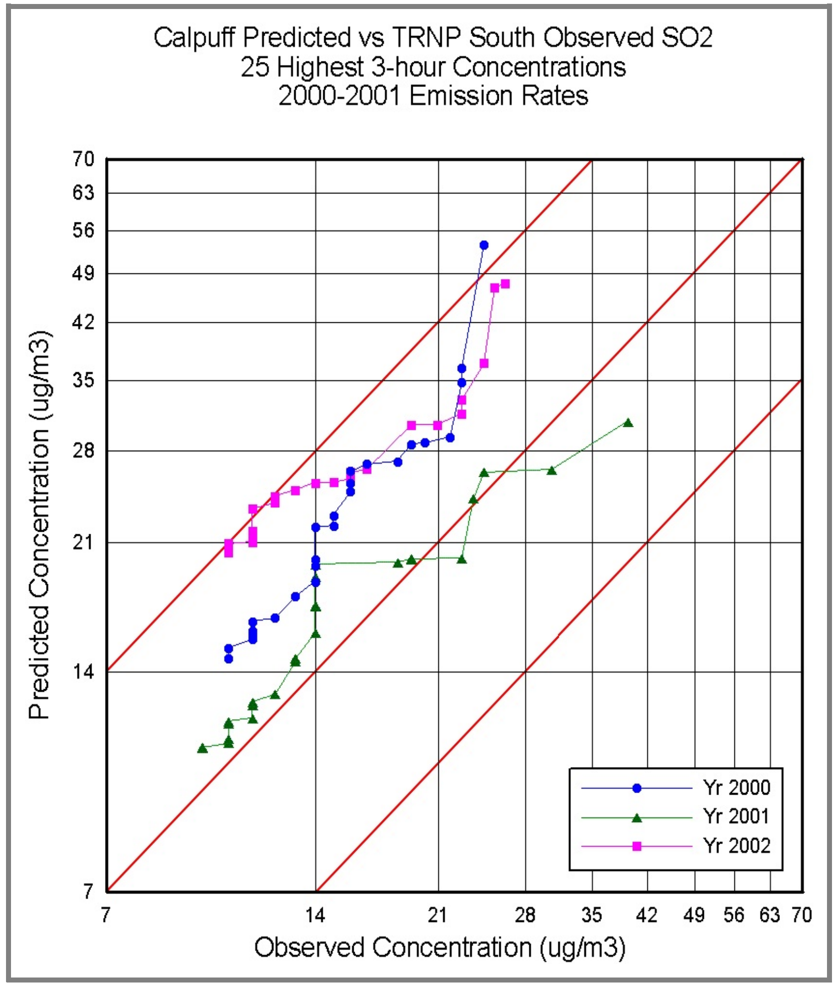

Second-high 3-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP South Unit, 2000-2001 Actual Emissions, Year 2000 Meteorological Data
36.6
34.1
36.1
37.2
32.8
35.0
36.3
37.1
38.0
37.4
33.5
37.1
37.3
36.7
36.6
36.7
36.8
36.8
35.6
36.3
36.5
37.0
36.9
35.7
34.4
35.4
36.0
36.1
37.9
35.9
35.3
35.2
34.8
34.9
34.7
34.7
34.5
34.3
34.5
36.5
34.5
34.6
34.2
35.1
33.7
33.9
33.5
35.1
38.5
33.5
34.2
33.3
33.2
35.7
38.6
= Monitor Location
34.8
36.4
38.3
0
2.5
5
7.5
10km


Second-high 3-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP South Unit, 2000-2001 Actual Emissions, Year 2001 Meteorological Data
15.0
13.5
13.8
16.7
13.3
14.7
14.3
18.3
22.1
16.9
13.8
14.4
15.7
15.9
15.7
15.5
14.2
14.2
14.5
15.3
16.1
16.7
17.8
13.8
14.3
15.0
15.8
16.5
22.2
17.7
18.0
13.8
14.2
14.9
15.3
15.9
16.3
16.7
17.6
20.7
16.1
17.7
17.6
20.0
18.4
19.9
20.5
21.7
25.1
19.5
23.7
22.8
21.5
23.7
25.7
= Monitor Location
24.9
26.5
27.4
0
2.5
5
7.5
10km

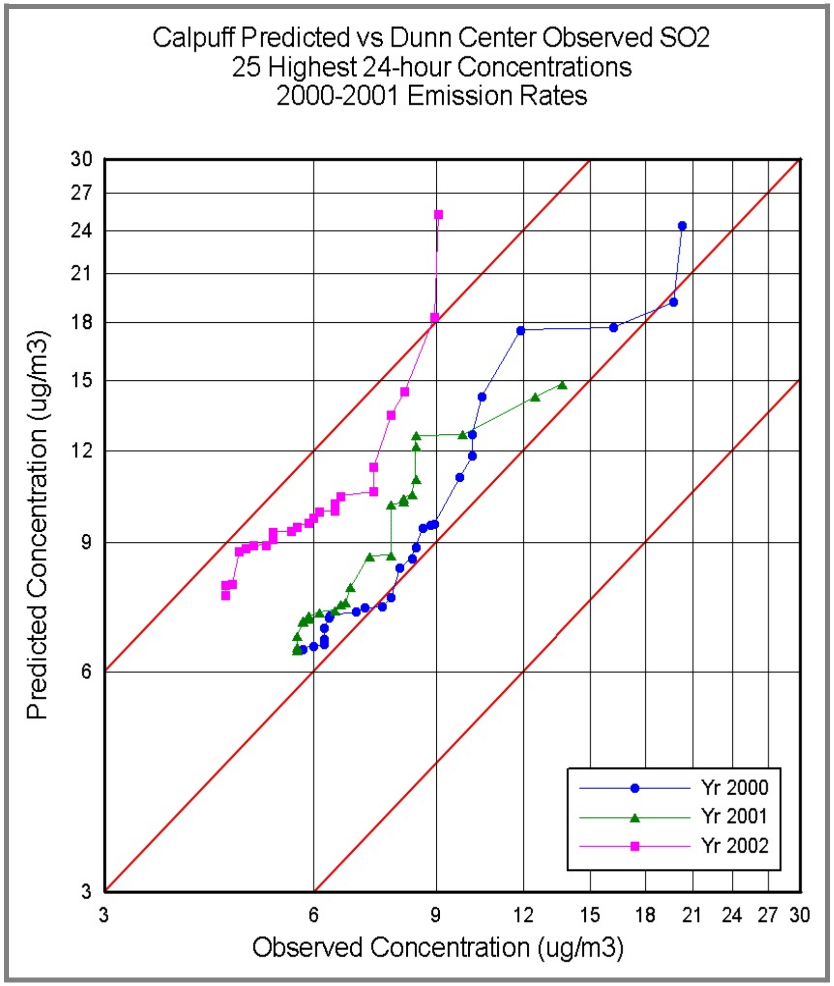

Second-high 3-hr SO2 Prediction (ug/m3) at Receptors and Monitoring Site
TRNP South Unit, 2000-2001 Actual Emissions, Year 2002 Meteorological Data
36.1
33.7
33.8
37.0
32.1
30.9
37.3
39.3
40.4
34.6
30.8
30.7
32.9
32.3
36.0
34.8
32.8
32.2
29.8
31.2
32.6
34.2
37.7
30.8
29.9
30.6
32.0
33.4
38.7
36.4
37.7
32.8
30.5
31.2
31.2
32.5
33.9
35.3
36.7
39.2
34.2
36.3
34.7
39.3
33.9
36.0
36.6
38.0
41.8
36.0
43.5
40.4
36.6
40.1
43.5
= Monitor Location
45.3
45.5
45.0
0
2.5
5
7.5
10km

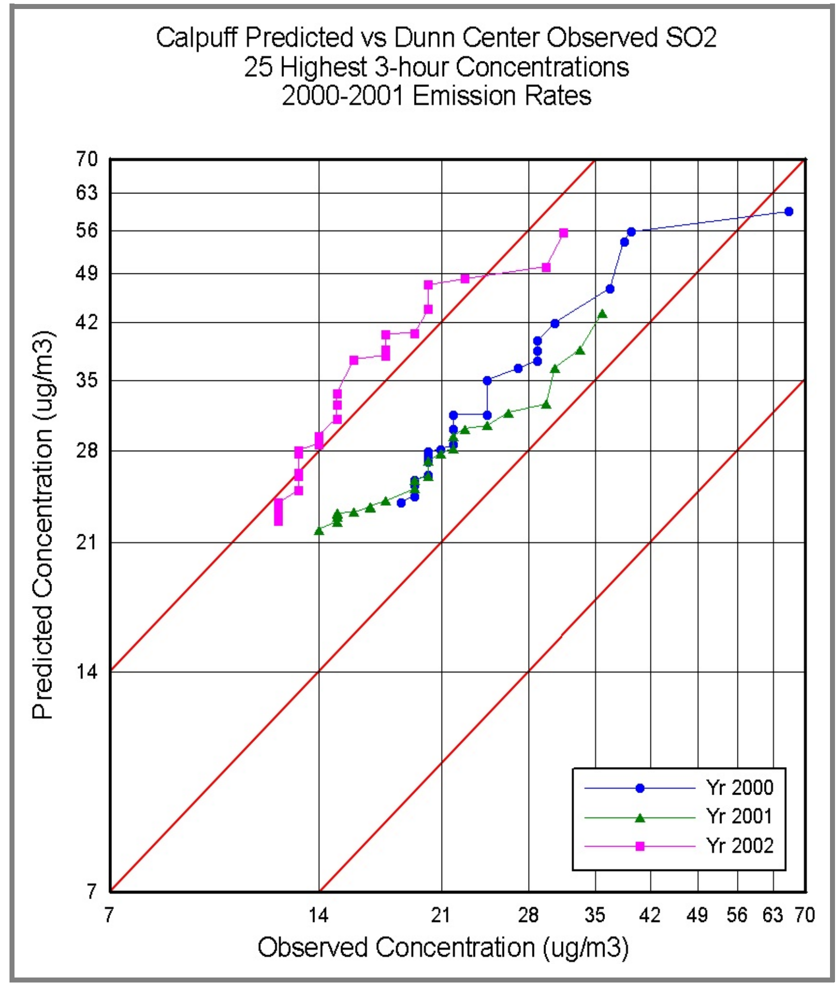
APPENDIX E. Graphs of predicted versus observed concentrations.

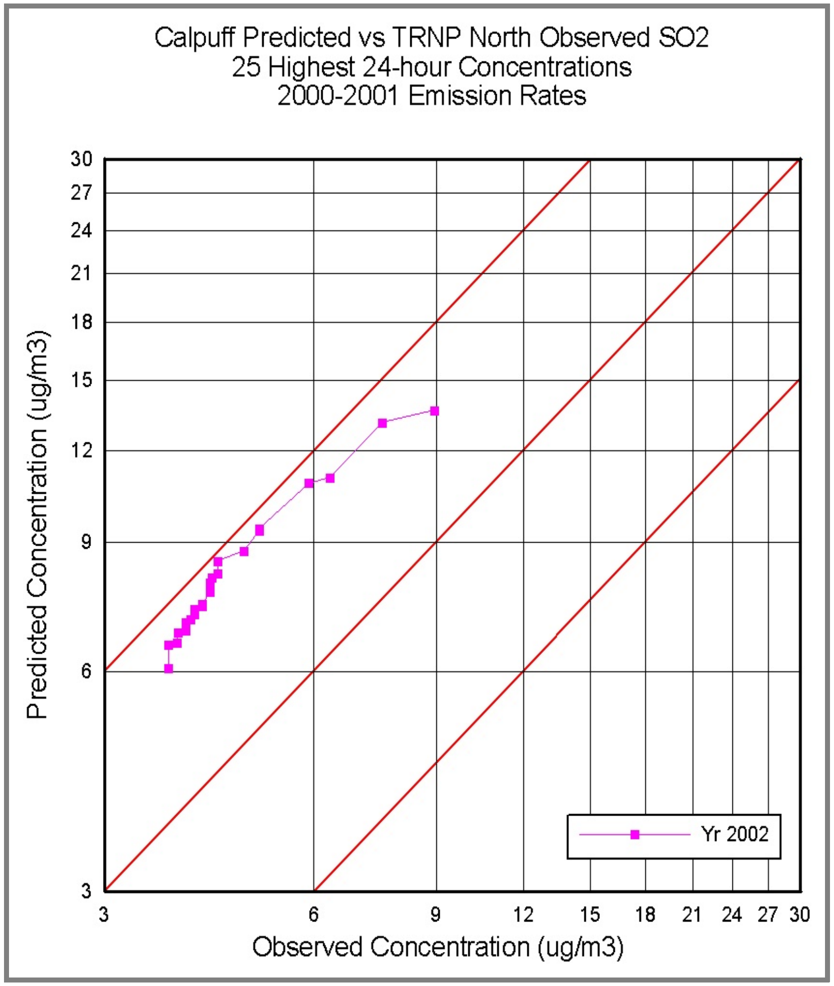
Additional graphs of highest predicted concentrations paired with highest observed (a.k.a. monitored) concentrations for 24-hour and 3-hour averaging periods are provided in this appendix. *The plotted model predicted concentrations shown in the maps include a background concentration of 1.5 ug/m3.*

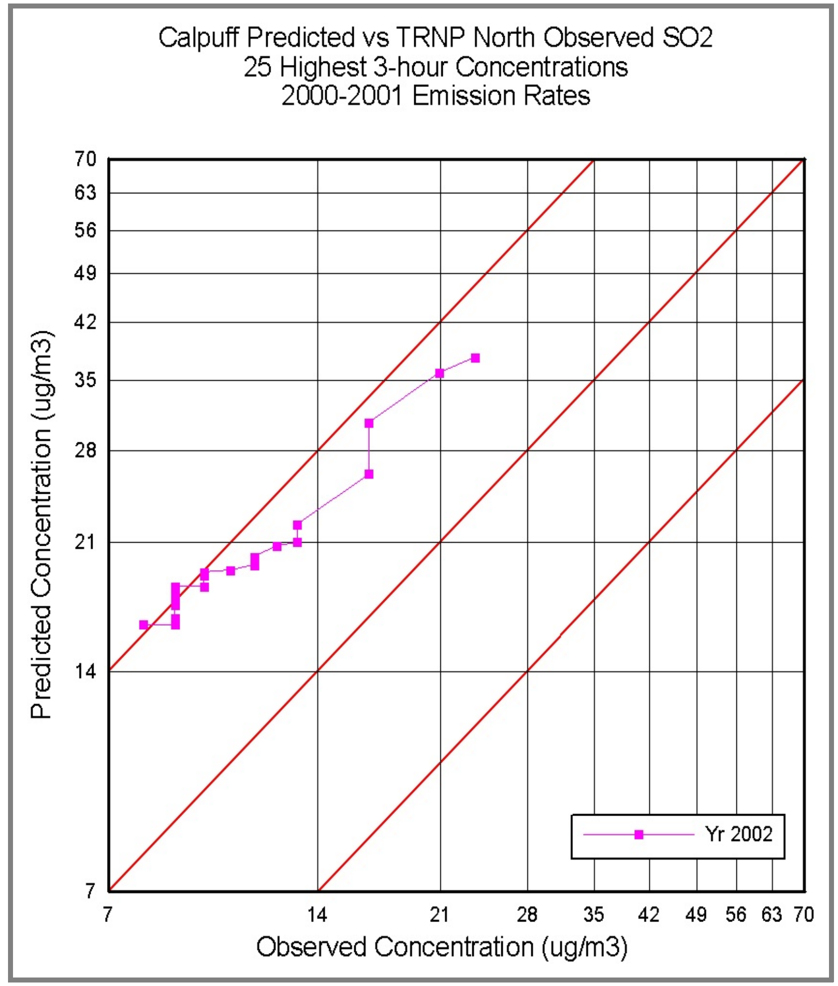


The graph for Calpuff predicted 24-hour concentrations using 2000-2001 sulfur dioxide emissions versus observed sulfur dioxide concentrations for the site of the monitor in the South Unit of the TRNP is shown and discussed earlier in this report.

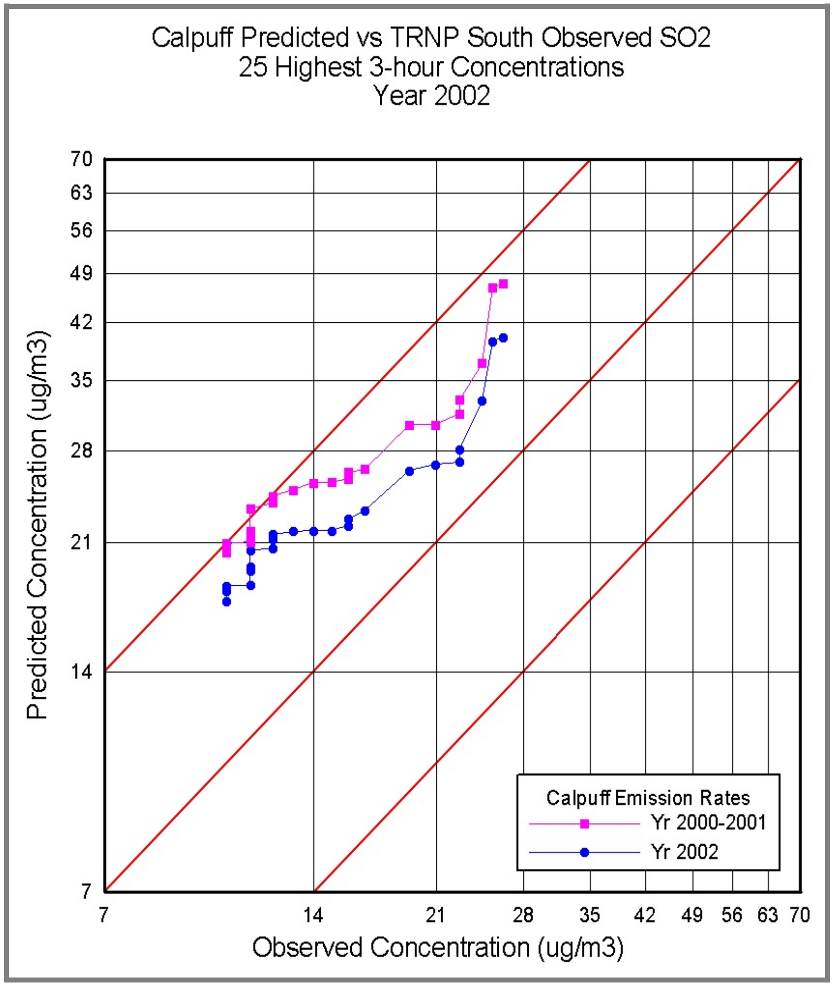

Calpuff Predicted vs Dunn Center Observed SO2
25 Highest 24-hour Concentrations
2000-2001 Emission Rates
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
30
27
24
21
18
15
12
9
6
3
3
6
9
12
15
18
21
24
27
30
Yr 2000
Yr 2001
Yr 2002

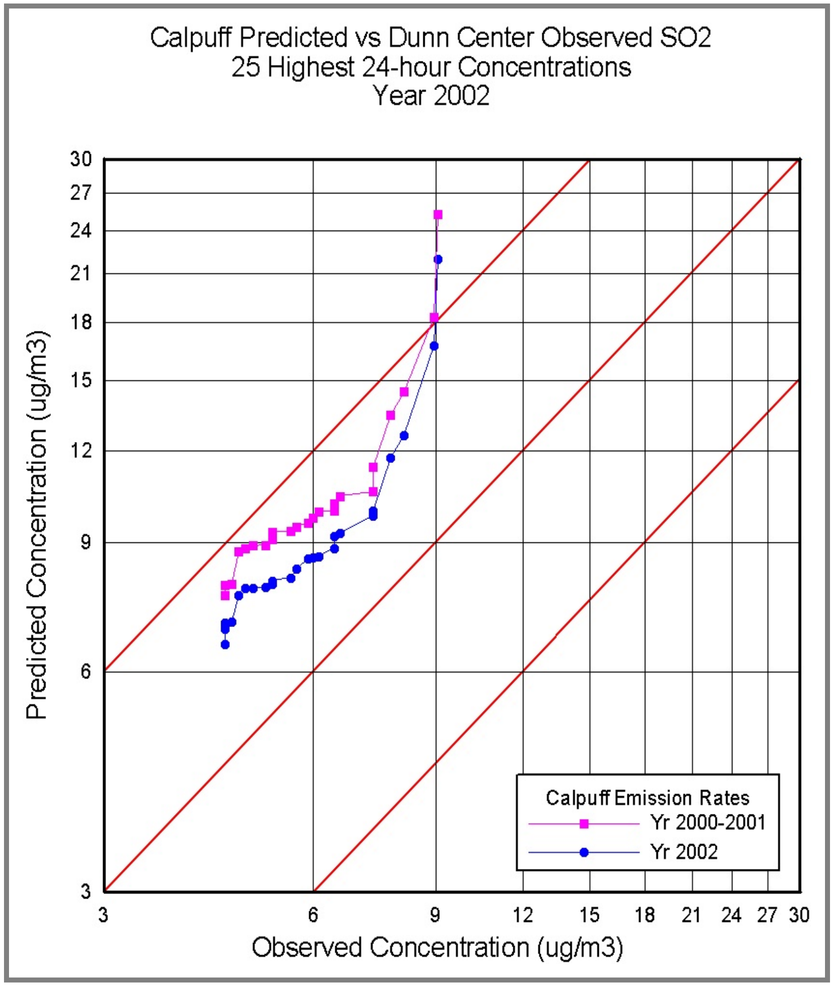

Calpuff Predicted vs Dunn Center Observed SO2
25 Highest 3-hour Concentrations
2000-2001 Emission Rates
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
70
63
56
49
42
35
28
21
14
7
7
14
21
28
35
42
49
56
63
70
Yr 2000
Yr 2001
Yr 2002

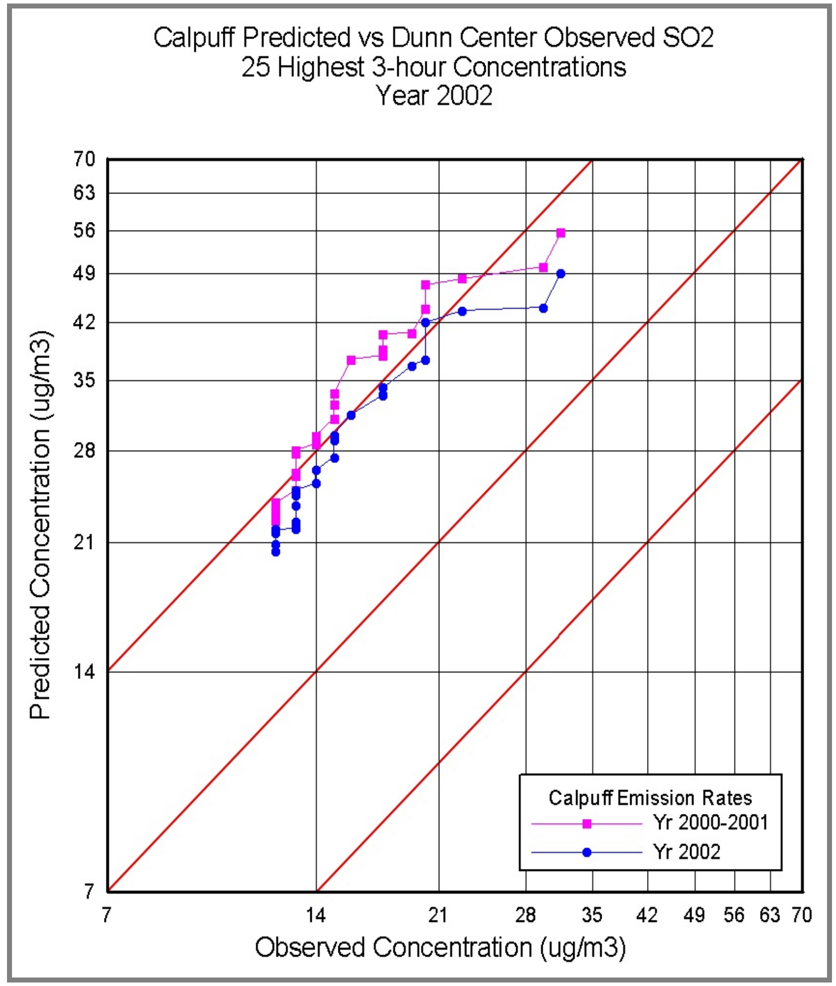

Calpuff Predicted vs TRNP North Observed SO2
25 Highest 24-hour Concentrations
2000-2001 Emission Rates
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
Yr 2002
30
27
24
21
18
15
12
9
6
3
3
6
9
12
15
18
21
24
27
30

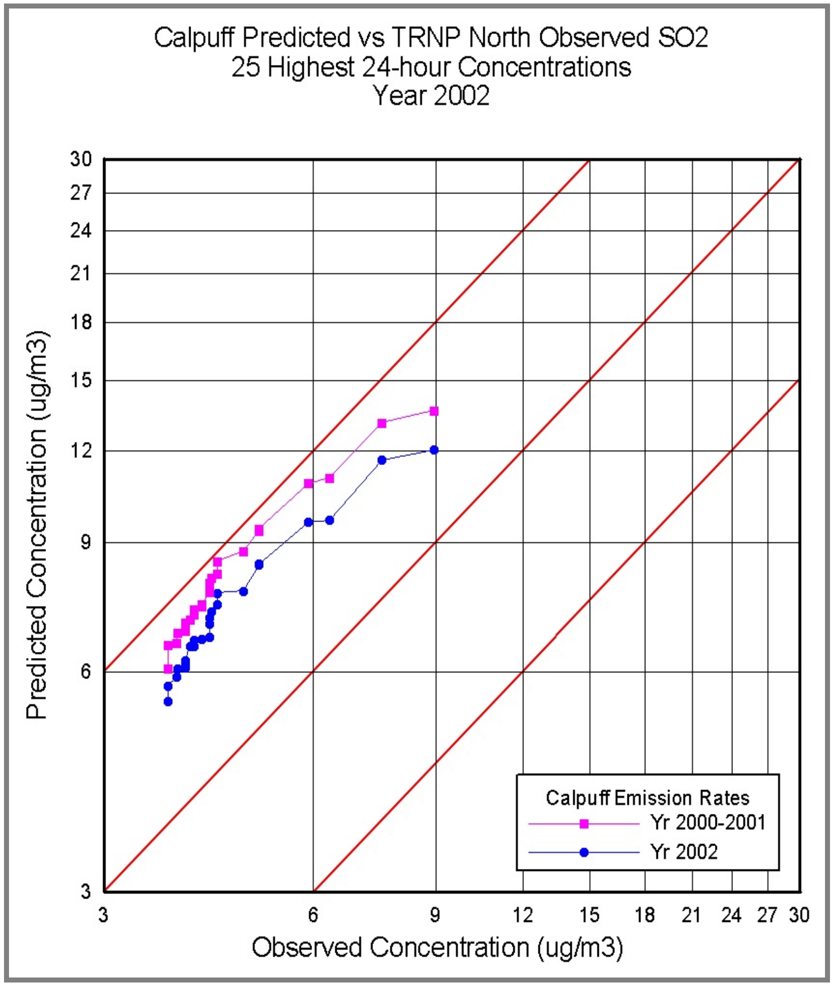

Calpuff Predicted vs TRNP North Observed SO2
25 Highest 3-hour Concentrations
2000-2001 Emission Rates
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
Yr 2002
70
63
56
49
42
35
28
21
14
7
7
14
21
28
35
42
49
56
63
70

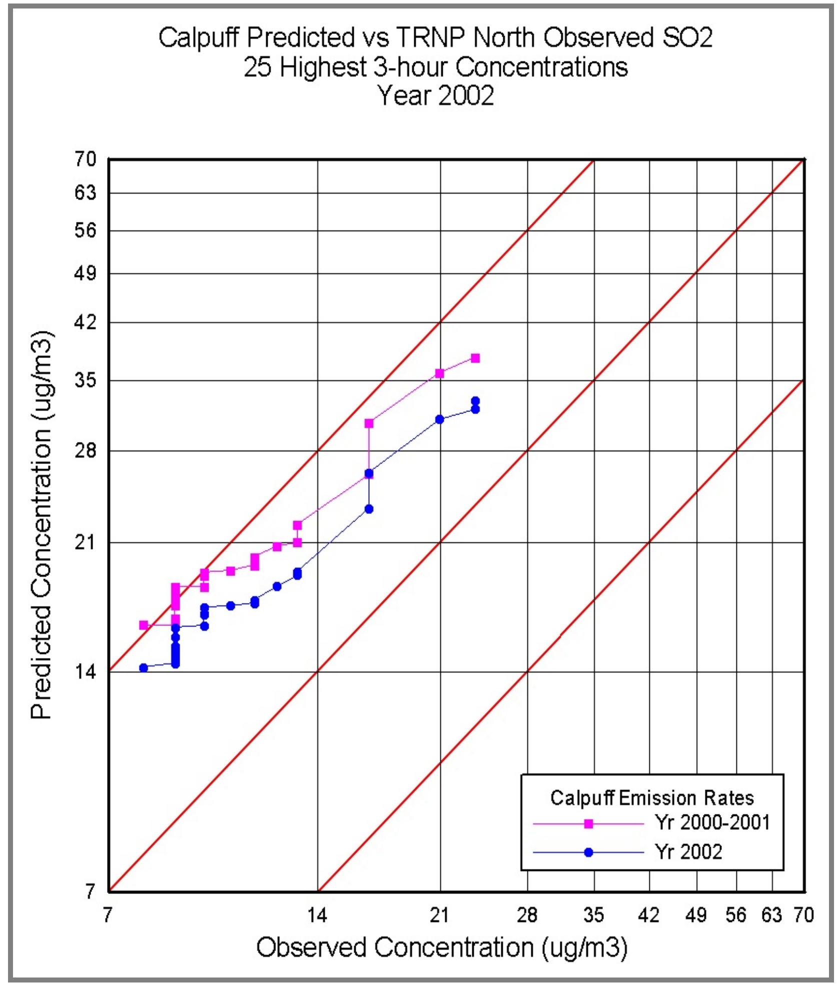
The graph for Calpuff predicted 24-hour concentrations using 2002 sulfur dioxide emissions versus observed sulfur dioxide concentrations for the site of the monitor in the South Unit of the TRNP is shown and discussed earlier in this report.



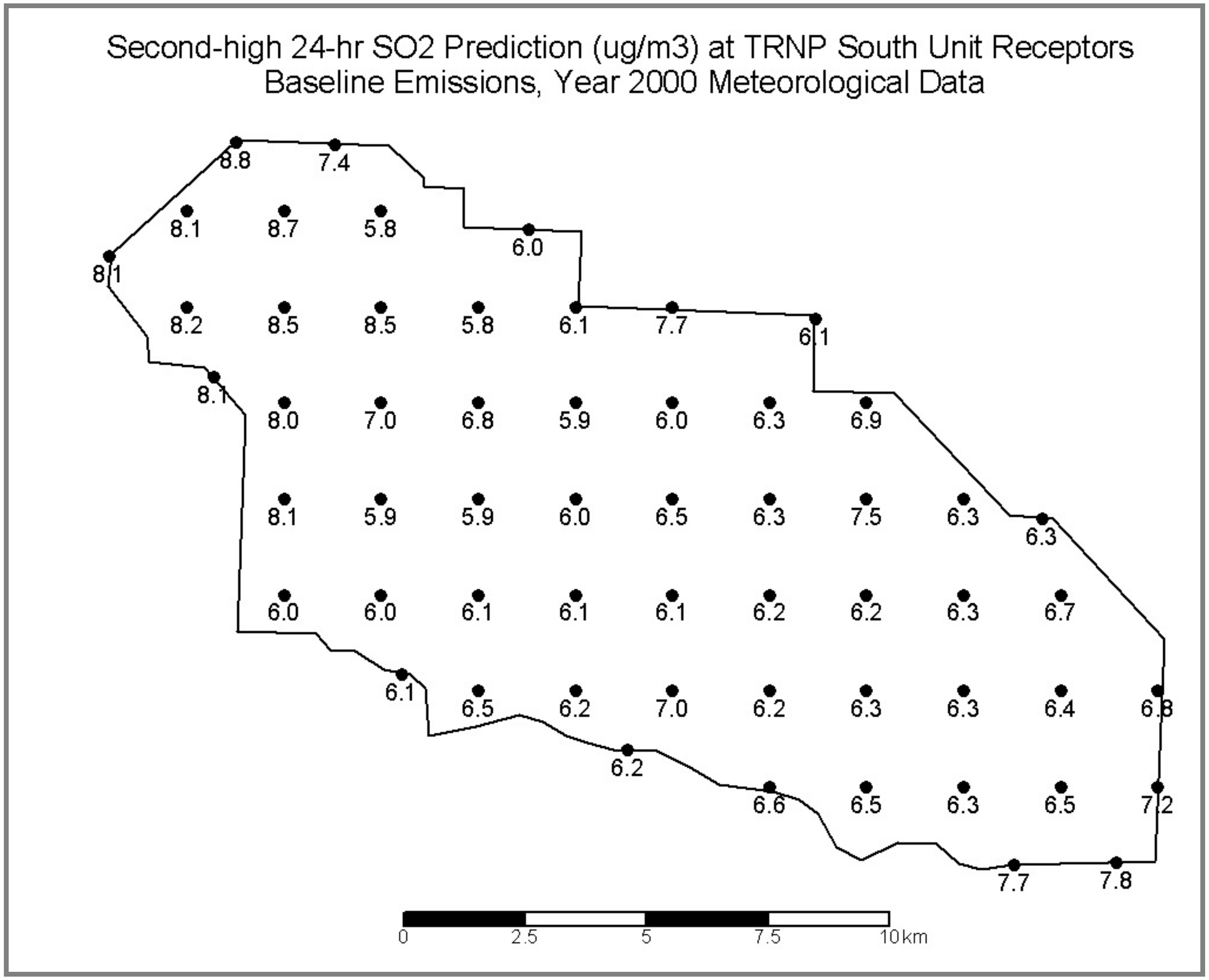

Calpuff Predicted vs Dunn Center Observed SO2
25 Highest 24-hour Concentrations
Year 2002
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
3
6
9
12
15
18
21
24
27
30
Calpuff Emission Rates
Yr 2000-2001
Yr 2002

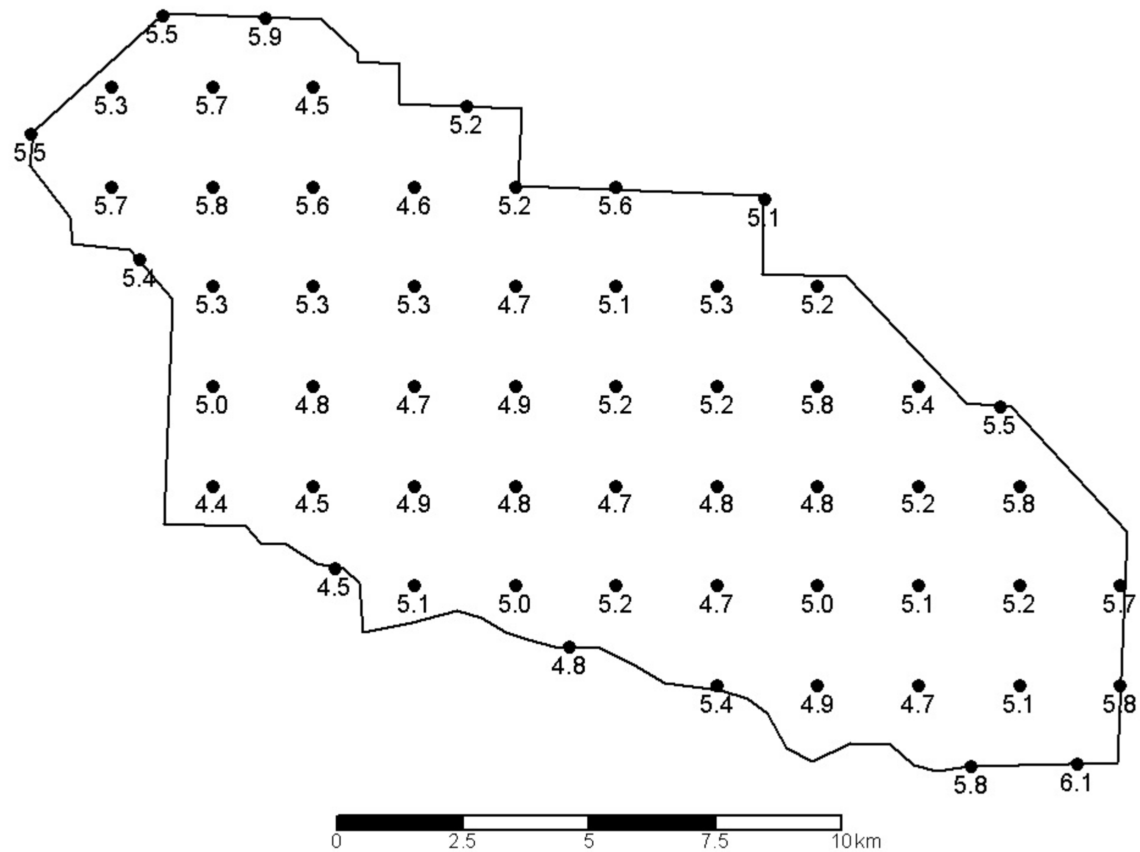

Calpuff Predicted vs Dunn Center Observed SO2
25 Highest 3-hour Concentrations
Year 2002
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
7
14
21
28
35
42
49
56
63
70
Calpuff Emission Rates
Yr 2000-2001
Yr 2002


Calpuff Predicted vs TRNP North Observed SO2
25 Highest 24-hour Concentrations
Year 2002
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
Calpuff Emission Rates
Yr 2000-2001
Yr 2002
30
27
24
21
18
15
12
9
6
3
3
6
9
12
15
18
21
24
27
30

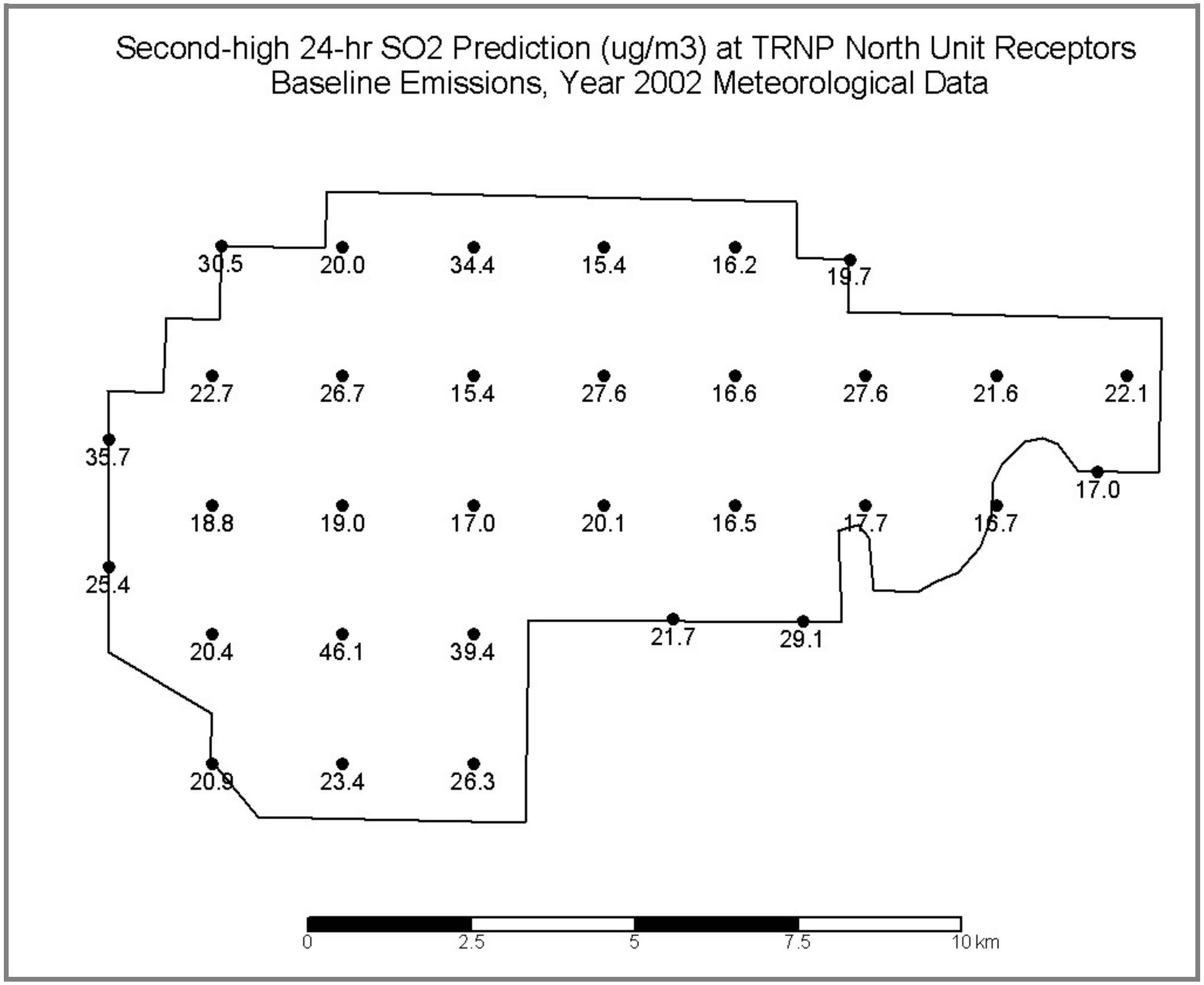

Calpuff Predicted vs TRNP North Observed SO2
25 Highest 3-hour Concentrations
Year 2002
Predicted Concentration (ug/m3)
Observed Concentration (ug/m3)
Calpuff Emission Rates
Yr 2000-2001
Yr 2002
70
63
56
49
42
35
28
21
14
7
7
14
21
28
35
42
49
56
63
70

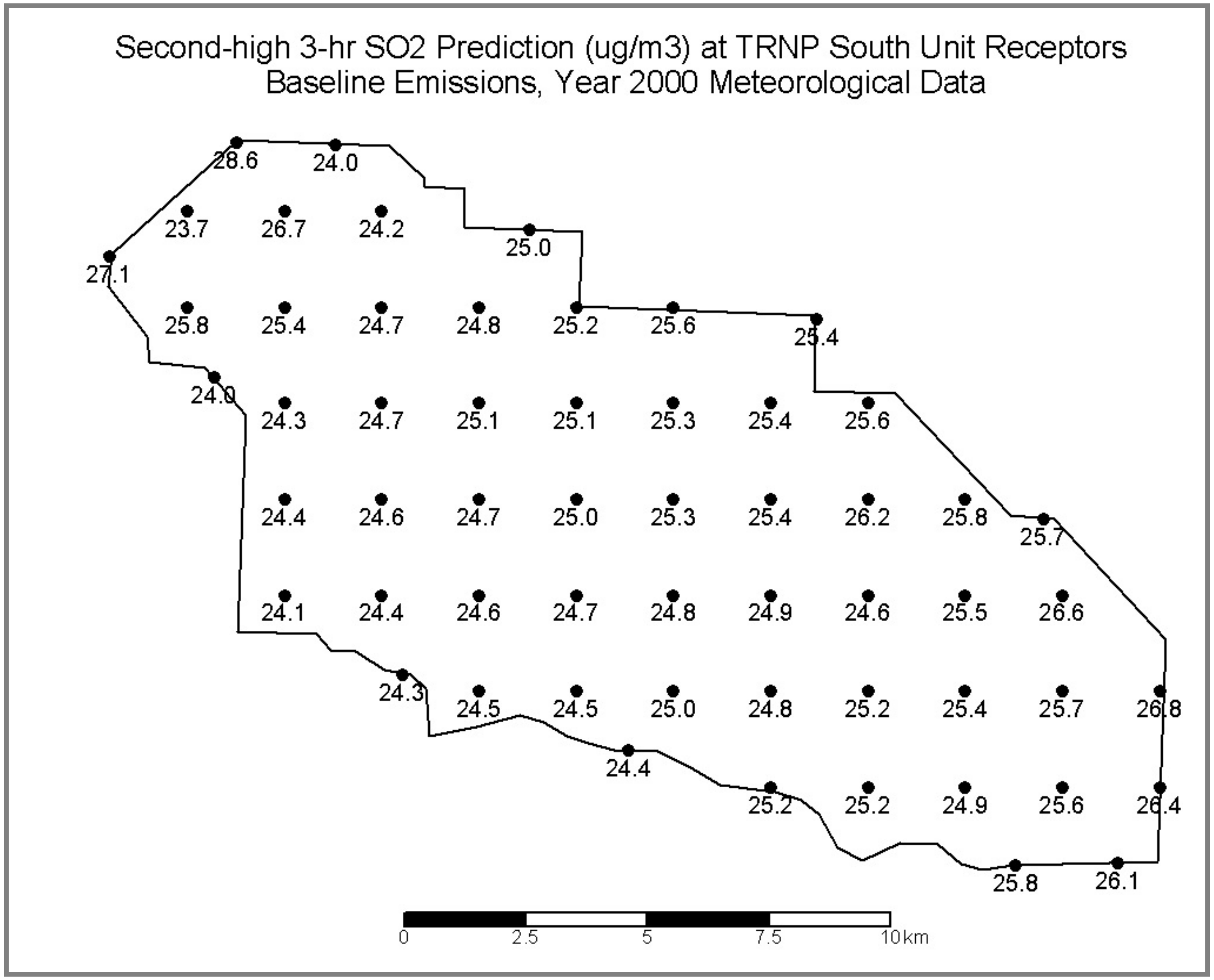
APPENDIX F. Maps of baseline concentrations at receptors.

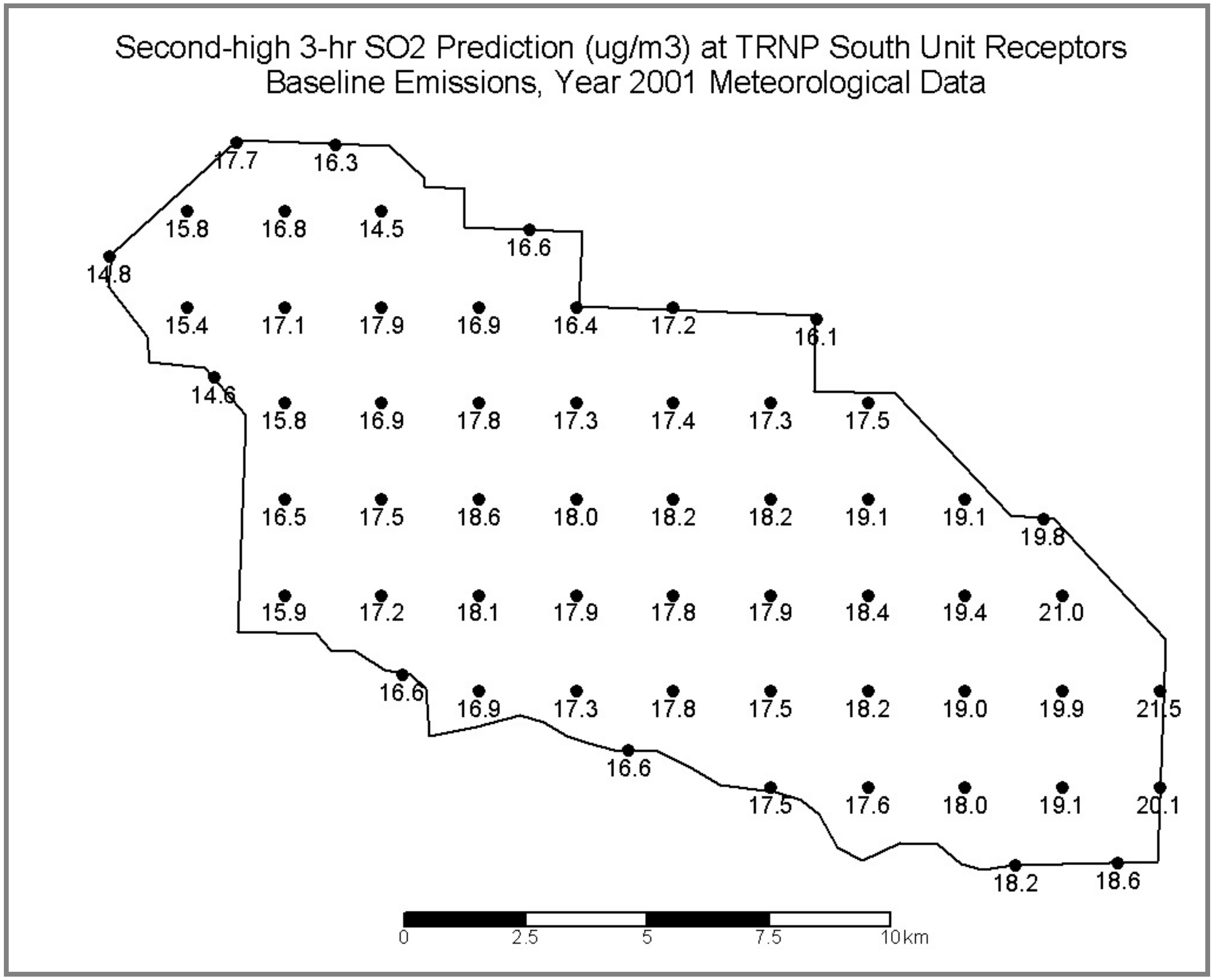




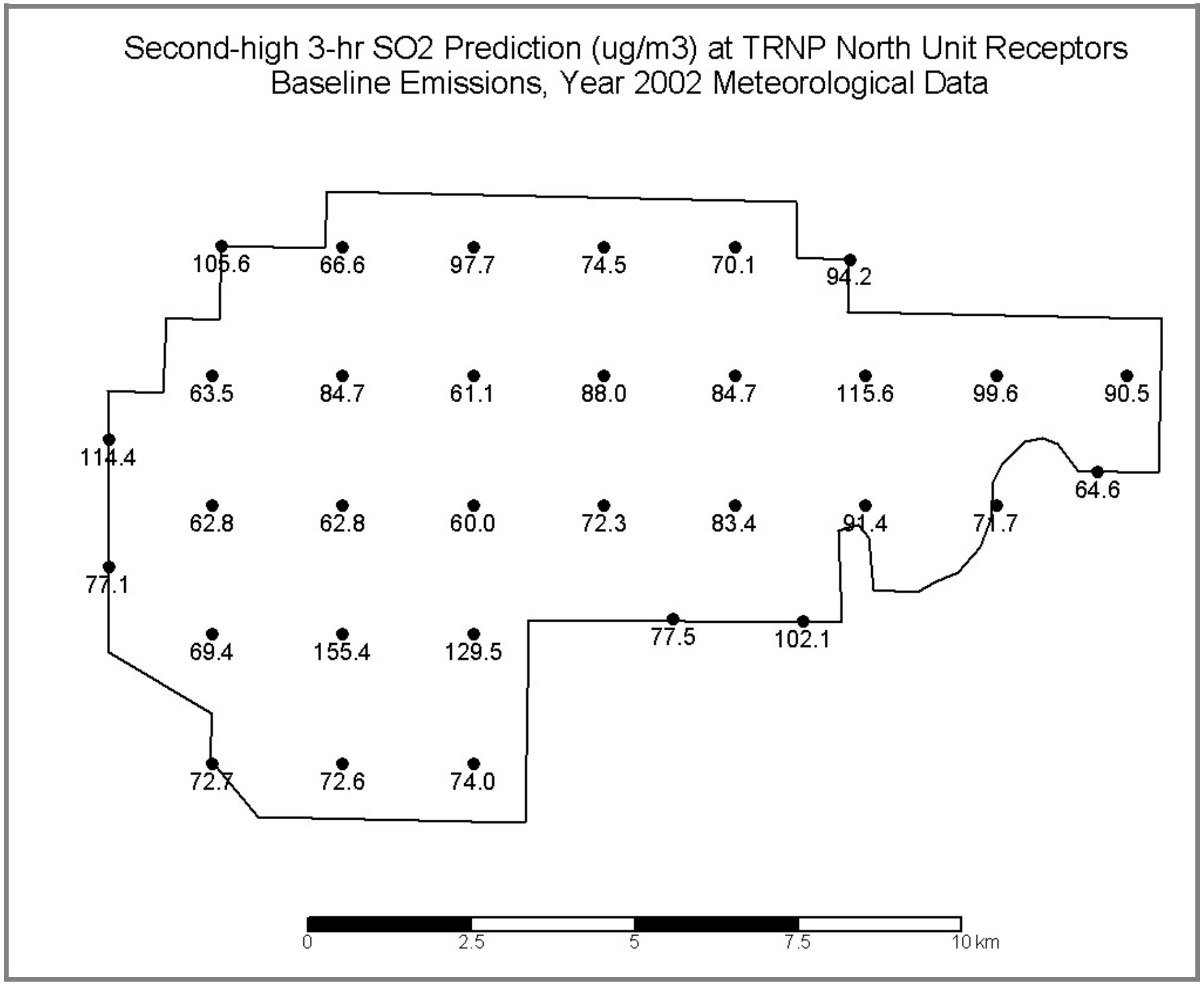
Second-high 24-hr SO2 Prediction (ug/m3) at TRNP South Unit Receptors
Baseline Emissions, Year 2001 Meteorological Data


Second-high 24-hr SO2 Prediction (ug/m3) at TRNP North Unit Receptors
Baseline Emissions, Year 2002 Meteorological Data
30.5
20.0
34.4
15.4
16.2
19.7
22.7
26.7
15.4
27.6
16.6
27.6
21.6
22.1
35.7
17.0
18.8
19.0
17.0
20.1
16.5
17.7
16.7
25.4
21.7
29.1
20.4
46.1
39.4
20.9
23.4
26.3
0
2.5
5
7.5
10 km


Second-high 3-hr SO2 Prediction (ug/m3) at TRNP South Unit Receptors
Baseline Emissions, Year 2000 Meteorological Data
28.6
24.0
23.7
26.7
24.2
25.0
27.1
25.8
25.4
24.7
24.8
25.2
25.6
25.4
24.0
24.3
24.7
25.1
25.1
25.3
25.4
25.6
24.4
24.6
24.7
25.0
25.3
25.4
26.2
25.8
25.7
24.1
24.4
24.6
24.7
24.8
24.9
24.6
25.5
26.6
24.3
24.5
24.5
25.0
24.8
25.2
25.4
25.7
26.8
24.4
25.2
25.2
24.9
25.6
26.4
25.8
26.1
0
2.5
5
7.5
10km



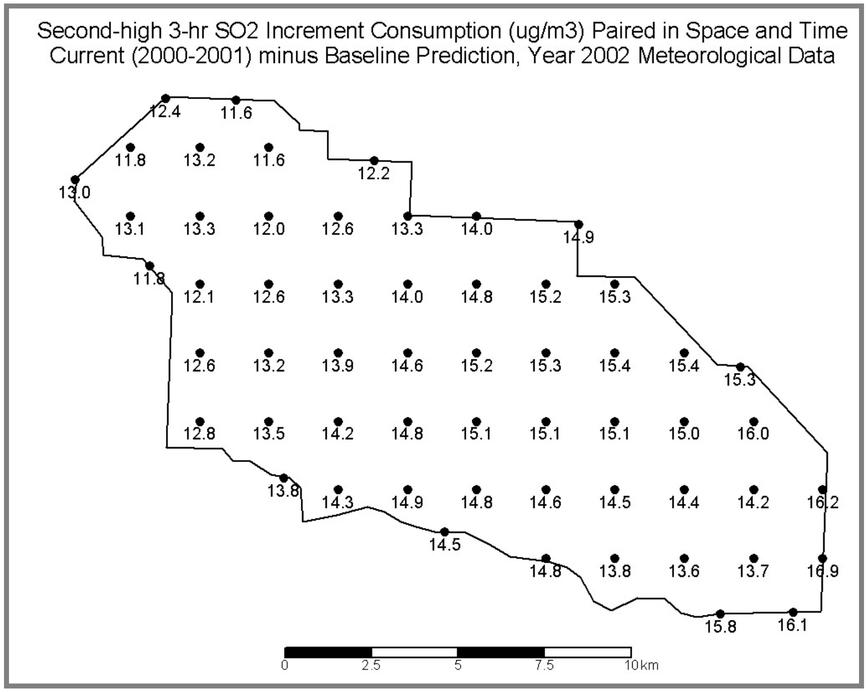
Second-high 3-hr SO2 Prediction (ug/m3) at TRNP South Unit Receptors
Baseline Emissions, Year 2001 Meteorological Data
17.7
16.3
15.8
16.8
14.5
16.6
14.8
15.4
17.1
17.9
16.9
16.4
17.2
16.1
14.6
15.8
16.9
17.8
17.3
17.4
17.3
17.5
16.5
17.5
18.6
18.0
18.2
18.2
19.1
19.1
19.8
15.9
17.2
18.1
17.9
17.8
17.9
18.4
19.4
21.0
16.6
16.9
17.3
17.8
17.5
18.2
19.0
19.9
21.5
16.6
17.5
17.6
18.0
19.1
20.1
18.2
18.6
0
2.5
5
7.5
10km

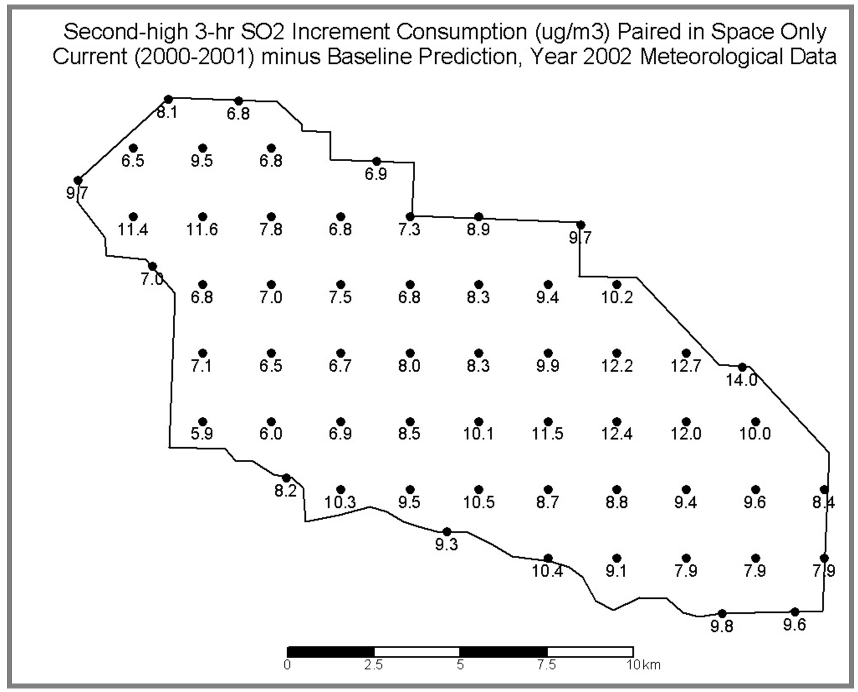


Second-high 3-hr SO2 Prediction (ug/m3) at TRNP North Unit Receptors
Baseline Emissions, Year 2002 Meteorological Data
105.6
66.6
97.7
74.5
70.1
94.2
63.5
84.7
61.1
88.0
84.7
115.6
99.6
90.5
114.4
64.6
62.8
62.8
60.0
72.3
83.4
91.4
71.7
77.1
69.4
155.4
129.5
77.5
102.1
72.7
72.6
74.0
0
2.5
5
7.5
10 km

APPENDIX G. Spatial variation of predicted second highest 3-hour ΔXs.

The federal Clean Air Act and rules allow one exceedance per year of 3-hour PSD Class I sulfur dioxide increments, with exceptions provided. An exceedance occurs when predicted deterioration is larger than the increment. The paired-in-space-and-time method and the paired-in-space-only method for calculating increment exceedances are explained on pages 25 - 28 of the protocol and on pages 29 - 33 of this report. The second highest predicted deterioration of 3-hour concentrations due to changes in emitted sulfur since PSD baseline when using 2002 meteorological data are provided in the two charts below – at left when using EPA's method and at right when using the Alternate method.





APPENDIX H. Protocol results data by Class I area by year.

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions With CONAI Sources

Results for TRNP SOUTH UNIT

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 57			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	17.8	14.8	16.9
Corresponding current concentration (ug/m3)	34.2	25.7	26.4
Corresponding baseline concentration (ug/m3)	16.4	10.9	9.5

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 57			
Number of receptors with at least one exceedance	5	0	57
Number of receptors with two or more exceedances	0	0	5
HSH deterioration among all receptors (ug/m3)	4.4	4.0	5.6
Corresponding current concentration (ug/m3)	8.5	6.4	10.4
Corresponding baseline concentration (ug/m3)	4.1	2.4	4.7

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 57			
Number of receptors with at least one exceedance	5	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	12.7	8.8	14.0
Corresponding current concentration (ug/m3)	37.4	27.4	37.7
Corresponding baseline concentration (ug/m3)	24.7	18.6	23.8

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 57			
Number of receptors with at least one exceedance	0	0	56
Number of receptors with two or more exceedances	0	0	30
HSH deterioration among all receptors (ug/m3)	2.8	1.8	6.6
Corresponding current concentration (ug/m3)	8.5	7.6	15.7
Corresponding baseline concentration (ug/m3)	5.8	5.8	9.1

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions With CONAI Sources

Results for TRNP NORTH UNIT

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

Total no. receptors in Class I area = 32	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	12.1	11.4	14.0
Corresponding current concentration (ug/m3)	28.4	18.7	14.7
Corresponding baseline concentration (ug/m3)	16.3	7.3	0.8

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

Total no. receptors in Class I area = 32	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	7
Number of receptors with two or more exceedances	0	0	2
HSH deterioration among all receptors (ug/m3)	3.6	3.6	5.1
Corresponding current concentration (ug/m3)	8.8	11.0	9.5
Corresponding baseline concentration (ug/m3)	5.2	7.4	4.4

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

Total no. receptors in Class I area = 32	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	-64.9	-37.0	-22.1
Corresponding current concentration (ug/m3)	27.2	22.6	37.9
Corresponding baseline concentration (ug/m3)	92.1	59.6	60.0

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

Total no. receptors in Class I area = 32	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	-13.3	-8.3	-3.3
Corresponding current concentration (ug/m3)	9.9	9.4	12.1
Corresponding baseline concentration (ug/m3)	23.3	17.7	15.4

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions With CONAI Sources

Results for TRNP ELKHORN RANCH

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2000   YR 2001   YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0         0         0
  Number of receptors with two or more exceedances         0         0         0

HSH deterioration among all receptors (ug/m3)              9.8       5.1       7.9
  Corresponding current concentration (ug/m3)             26.4       6.1      31.3
  Corresponding baseline concentration (ug/m3)            16.6       1.0      23.4
```

```
CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2000   YR 2001   YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0         0         0
  Number of receptors with two or more exceedances         0         0         0

HSH deterioration among all receptors (ug/m3)              0.6       1.0       1.2
  Corresponding current concentration (ug/m3)              0.8       5.2       8.3
  Corresponding baseline concentration (ug/m3)             0.2       4.1       7.1
```

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2000   YR 2001   YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0         0         0
  Number of receptors with two or more exceedances         0         0         0

HSH deterioration among all receptors (ug/m3)            -34.6     -32.3     -18.9
  Corresponding current concentration (ug/m3)             28.1      15.1      38.0
  Corresponding baseline concentration (ug/m3)            62.7      47.4      56.9
```

```
CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2000   YR 2001   YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0         0         0
  Number of receptors with two or more exceedances         0         0         0

HSH deterioration among all receptors (ug/m3)             -7.8     -12.8      -6.2
  Corresponding current concentration (ug/m3)             10.5       5.3      15.0
  Corresponding baseline concentration (ug/m3)            18.3      18.1      21.2
```

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions With CONAI Sources

Results for LOSTWOOD NWA

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	10.3	12.3	8.7
Corresponding current concentration (ug/m3)	24.9	27.1	13.5
Corresponding baseline concentration (ug/m3)	14.6	14.8	4.9

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	9	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	2.6	4.2	3.2
Corresponding current concentration (ug/m3)	5.2	7.3	8.9
Corresponding baseline concentration (ug/m3)	2.6	3.2	5.8

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	7.3	5.4	9.6
Corresponding current concentration (ug/m3)	24.5	31.3	33.3
Corresponding baseline concentration (ug/m3)	17.2	25.9	23.7

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	9	4
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	2.1	1.9	3.3
Corresponding current concentration (ug/m3)	8.2	10.1	8.6
Corresponding baseline concentration (ug/m3)	6.1	8.2	5.4

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions With CONAI Sources

Results for MEDICINE LAKE NWA

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	4.9	6.1	7.6
Corresponding current concentration (ug/m3)	11.4	12.0	13.1
Corresponding baseline concentration (ug/m3)	6.5	5.9	5.5

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	1.3	1.7	1.8
Corresponding current concentration (ug/m3)	3.5	6.0	3.6
Corresponding baseline concentration (ug/m3)	2.2	4.2	1.7

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	4.4	3.4	3.6
Corresponding current concentration (ug/m3)	12.5	12.1	13.1
Corresponding baseline concentration (ug/m3)	8.1	8.7	9.4

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY

Meteorological Data: RUC2d	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	0.1	1.7	1.2
Corresponding current concentration (ug/m3)	3.7	6.1	5.4
Corresponding baseline concentration (ug/m3)	3.6	4.4	4.2

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions With CONAI Sources

Results for FT PECK RESERVATION

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	9.4	7.2	6.6
Corresponding current concentration (ug/m3)	13.6	16.8	10.6
Corresponding baseline concentration (ug/m3)	4.2	9.5	4.0

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	2.7	1.6	2.4
Corresponding current concentration (ug/m3)	6.0	5.2	5.3
Corresponding baseline concentration (ug/m3)	3.2	3.6	3.0

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	6.8	6.3	6.1
Corresponding current concentration (ug/m3)	16.6	14.1	16.2
Corresponding baseline concentration (ug/m3)	9.7	7.8	10.1

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	2.8	1.5	2.4
Corresponding current concentration (ug/m3)	5.5	4.5	6.0
Corresponding baseline concentration (ug/m3)	2.7	3.0	3.6

Results for TRNP SOUTH UNIT

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

Total no. receptors in Class I area = 57	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	14.3	14.4	14.6
Corresponding current concentration (ug/m3)	25.6	25.3	16.5
Corresponding baseline concentration (ug/m3)	11.2	10.9	1.9

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

Total no. receptors in Class I area = 57	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	43
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	3.7	3.4	4.6
Corresponding current concentration (ug/m3)	7.6	5.8	8.0
Corresponding baseline concentration (ug/m3)	3.9	2.4	3.3

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

Total no. receptors in Class I area = 57	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	11.0	7.0	12.2
Corresponding current concentration (ug/m3)	35.6	25.7	36.0
Corresponding baseline concentration (ug/m3)	24.7	18.6	23.8

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

Total no. receptors in Class I area = 57	YR 2000	YR 2001	YR 2002
Number of receptors with at least one exceedance	0	0	49
Number of receptors with two or more exceedances	0	0	22
HSH deterioration among all receptors (ug/m3)	2.3	1.5	5.8
Corresponding current concentration (ug/m3)	8.1	7.3	15.0
Corresponding baseline concentration (ug/m3)	5.8	5.8	9.2

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions Without CONAI Sources

Results for TRNP NORTH UNIT

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 32			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	9.8	11.3	13.9
Corresponding current concentration (ug/m3)	24.8	16.2	14.7
Corresponding baseline concentration (ug/m3)	15.1	4.9	0.8

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 32			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	3.2	3.0	4.4
Corresponding current concentration (ug/m3)	8.4	9.8	8.8
Corresponding baseline concentration (ug/m3)	5.2	6.8	4.4

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 32			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	-67.7	-38.6	-24.6
Corresponding current concentration (ug/m3)	24.4	21.0	35.4
Corresponding baseline concentration (ug/m3)	92.1	59.6	60.0

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 32			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	-14.2	-8.7	-4.0
Corresponding current concentration (ug/m3)	9.1	8.9	11.3
Corresponding baseline concentration (ug/m3)	23.3	17.7	15.4

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions Without CONAI Sources

Results for TRNP ELKHORN RANCH

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	8.1	4.4	7.0
Corresponding current concentration (ug/m3)	14.1	12.3	11.3
Corresponding baseline concentration (ug/m3)	6.0	7.9	4.2

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	0.6	0.9	0.9
Corresponding current concentration (ug/m3)	0.7	1.6	2.3
Corresponding baseline concentration (ug/m3)	0.1	0.7	1.5

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	-35.6	-33.2	-21.4
Corresponding current concentration (ug/m3)	27.1	14.2	35.4
Corresponding baseline concentration (ug/m3)	62.7	47.4	56.9

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	-8.4	-13.0	-7.0
Corresponding current concentration (ug/m3)	9.9	5.0	14.2
Corresponding baseline concentration (ug/m3)	18.3	18.1	21.2

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions Without CONAI Sources

Results for LOSTWOOD NWA

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	9.8	10.6	7.6
Corresponding current concentration (ug/m3)	24.4	25.4	36.2
Corresponding baseline concentration (ug/m3)	14.6	14.8	28.6

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	2.5	3.6	2.6
Corresponding current concentration (ug/m3)	8.3	6.7	8.8
Corresponding baseline concentration (ug/m3)	5.8	3.2	6.2

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	6.8	5.2	9.4
Corresponding current concentration (ug/m3)	24.0	31.1	33.1
Corresponding baseline concentration (ug/m3)	17.2	25.9	23.7

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 9			
Number of receptors with at least one exceedance	0	0	3
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	1.8	1.7	2.7
Corresponding current concentration (ug/m3)	7.9	9.9	8.1
Corresponding baseline concentration (ug/m3)	6.1	8.2	5.4

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions Without CONAI Sources

Results for MEDICINE LAKE NWA

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	4.1	5.7	7.3
Corresponding current concentration (ug/m3)	10.6	11.6	12.7
Corresponding baseline concentration (ug/m3)	6.5	5.9	5.5

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	1.1	1.5	1.7
Corresponding current concentration (ug/m3)	3.4	5.7	3.5
Corresponding baseline concentration (ug/m3)	2.2	4.2	1.7

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	3.9	3.0	3.3
Corresponding current concentration (ug/m3)	12.0	11.7	12.7
Corresponding baseline concentration (ug/m3)	8.1	8.7	9.4

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY — Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 1			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	0.0	1.4	1.0
Corresponding current concentration (ug/m3)	3.6	5.8	5.2
Corresponding baseline concentration (ug/m3)	3.6	4.4	4.2

CALMET-CALPUFF Predictions for Year 2000-2001 Emissions Without CONAI Sources

Results for FT PECK RESERVATION

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T   Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	9.2	6.4	6.2
Corresponding current concentration (ug/m3)	13.4	15.9	10.1
Corresponding baseline concentration (ug/m3)	4.2	9.5	4.0

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S&T   Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	2.4	1.4	2.1
Corresponding current concentration (ug/m3)	5.6	5.0	5.1
Corresponding baseline concentration (ug/m3)	3.2	3.6	3.0

CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY   Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	6.0	5.4	5.4
Corresponding current concentration (ug/m3)	15.8	13.2	15.5
Corresponding baseline concentration (ug/m3)	9.7	7.8	10.1

CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method: PAIRED IN S ONLY   Meteorological Data: RUC2d

	YR 2000	YR 2001	YR 2002
Total no. receptors in Class I area = 4			
Number of receptors with at least one exceedance	0	0	0
Number of receptors with two or more exceedances	0	0	0
HSH deterioration among all receptors (ug/m3)	2.7	1.4	2.2
Corresponding current concentration (ug/m3)	5.4	4.4	5.7
Corresponding baseline concentration (ug/m3)	2.7	3.0	3.6

APPENDIX I. 2002-2003 actual emissions results data by Class I area for year 2002.

CALMET-CALPUFF Predictions for Year 2002-2003 Emissions With CONAI Sources

Results for TRNP SOUTH UNIT

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)             14.9
  Corresponding current concentration (ug/m3)            24.4
  Corresponding baseline concentration (ug/m3)             9.5


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance        34
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              4.7
  Corresponding current concentration (ug/m3)            16.2
  Corresponding baseline concentration (ug/m3)           11.5


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)             10.9
  Corresponding current concentration (ug/m3)            34.7
  Corresponding baseline concentration (ug/m3)           23.8


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance        27
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              4.9
  Corresponding current concentration (ug/m3)            14.0
  Corresponding baseline concentration (ug/m3)             9.1
```

```
CALMET-CALPUFF Predictions for Year 2002-2003 Emissions With CONAI Sources

Results for TRNP NORTH UNIT



CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)            14.0
  Corresponding current concentration (ug/m3)            14.7
  Corresponding baseline concentration (ug/m3)            0.8


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)             4.5
  Corresponding current concentration (ug/m3)            14.7
  Corresponding baseline concentration (ug/m3)           10.3


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)           -26.0
  Corresponding current concentration (ug/m3)            34.0
  Corresponding baseline concentration (ug/m3)           60.0


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)            -4.3
  Corresponding current concentration (ug/m3)            11.0
  Corresponding baseline concentration (ug/m3)           15.4
```

```
CALMET-CALPUFF Predictions for Year 2002-2003 Emissions With CONAI Sources

Results for TRNP ELKHORN RANCH



CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance        0
  Number of receptors with two or more exceedances        0

HSH deterioration among all receptors (ug/m3)              5.8
  Corresponding current concentration (ug/m3)             21.6
  Corresponding baseline concentration (ug/m3)            15.8


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance        0
  Number of receptors with two or more exceedances        0

HSH deterioration among all receptors (ug/m3)              0.7
  Corresponding current concentration (ug/m3)              2.2
  Corresponding baseline concentration (ug/m3)             1.5


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance        0
  Number of receptors with two or more exceedances        0

HSH deterioration among all receptors (ug/m3)            -22.6
  Corresponding current concentration (ug/m3)             34.2
  Corresponding baseline concentration (ug/m3)            56.9


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance        0
  Number of receptors with two or more exceedances        0

HSH deterioration among all receptors (ug/m3)             -8.0
  Corresponding current concentration (ug/m3)             13.2
  Corresponding baseline concentration (ug/m3)            21.2
```

```
CALMET-CALPUFF Predictions for Year 2002-2003 Emissions With CONAI Sources

Results for LOSTWOOD NWA



CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              7.1
  Corresponding current concentration (ug/m3)              7.6
  Corresponding baseline concentration (ug/m3)             0.4


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              2.5
  Corresponding current concentration (ug/m3)              4.9
  Corresponding baseline concentration (ug/m3)             2.4


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              6.8
  Corresponding current concentration (ug/m3)             30.5
  Corresponding baseline concentration (ug/m3)            23.7


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              2.5
  Corresponding current concentration (ug/m3)              7.9
  Corresponding baseline concentration (ug/m3)             5.4
```

CALMET-CALPUFF Predictions for Year 2002-2003 Emissions With CONAI Sources

Results for MEDICINE LAKE NWA

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              7.1
  Corresponding current concentration (ug/m3)            12.5
  Corresponding baseline concentration (ug/m3)             5.5


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              1.5
  Corresponding current concentration (ug/m3)              4.4
  Corresponding baseline concentration (ug/m3)             2.9


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              3.1
  Corresponding current concentration (ug/m3)             12.5
  Corresponding baseline concentration (ug/m3)             9.4


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              0.6
  Corresponding current concentration (ug/m3)              4.8
  Corresponding baseline concentration (ug/m3)             4.2
```

```
CALMET-CALPUFF Predictions for Year 2002-2003 Emissions With CONAI Sources

Results for FT PECK RESERVATION



CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              6.1
  Corresponding current concentration (ug/m3)            10.1
  Corresponding baseline concentration (ug/m3)             4.0


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              1.7
  Corresponding current concentration (ug/m3)              5.9
  Corresponding baseline concentration (ug/m3)             4.1


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              5.0
  Corresponding current concentration (ug/m3)             15.0
  Corresponding baseline concentration (ug/m3)            10.1


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITH    sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              2.0
  Corresponding current concentration (ug/m3)              5.6
  Corresponding baseline concentration (ug/m3)             3.6
```

CALMET-CALPUFF Predictions for Year 2002-2003 Emissions Without CONAI Sources

Results for TRNP SOUTH UNIT

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)             12.7
  Corresponding current concentration (ug/m3)             26.3
  Corresponding baseline concentration (ug/m3)            13.6


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance         1
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              4.0
  Corresponding current concentration (ug/m3)             12.3
  Corresponding baseline concentration (ug/m3)             8.4


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              9.7
  Corresponding current concentration (ug/m3)             33.5
  Corresponding baseline concentration (ug/m3)            23.8


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP SOUTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area = 57
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              4.4
  Corresponding current concentration (ug/m3)             13.5
  Corresponding baseline concentration (ug/m3)             9.1
```

CALMET-CALPUFF Predictions for Year 2002-2003 Emissions Without CONAI Sources

Results for TRNP NORTH UNIT

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T           Meteorological Data: RUC2d
                                                         YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)             13.9
  Corresponding current concentration (ug/m3)             14.7
  Corresponding baseline concentration (ug/m3)             0.8


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T           Meteorological Data: RUC2d
                                                         YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              3.7
  Corresponding current concentration (ug/m3)             14.0
  Corresponding baseline concentration (ug/m3)            10.3


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY        Meteorological Data: RUC2d
                                                         YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)            -27.6
  Corresponding current concentration (ug/m3)             32.4
  Corresponding baseline concentration (ug/m3)            60.0


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP NORTH UNIT
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY        Meteorological Data: RUC2d
                                                         YR 2002
Total no. receptors in Class I area = 32
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)             -4.9
  Corresponding current concentration (ug/m3)             10.5
  Corresponding baseline concentration (ug/m3)            15.4
```

CALMET-CALPUFF Predictions for Year 2002-2003 Emissions Without CONAI Sources

Results for TRNP ELKHORN RANCH

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              5.7
  Corresponding current concentration (ug/m3)            21.5
  Corresponding baseline concentration (ug/m3)            15.8
```

```
CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              0.7
  Corresponding current concentration (ug/m3)              2.2
  Corresponding baseline concentration (ug/m3)             1.5
```

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)            -24.4
  Corresponding current concentration (ug/m3)            32.5
  Corresponding baseline concentration (ug/m3)            56.9
```

```
CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for TRNP ELKHORN RANCH
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)             -8.5
  Corresponding current concentration (ug/m3)            12.7
  Corresponding baseline concentration (ug/m3)            21.2
```

CALMET-CALPUFF Predictions for Year 2002-2003 Emissions Without CONAI Sources

Results for LOSTWOOD NWA

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)               6.1
  Corresponding current concentration (ug/m3)              29.1
  Corresponding baseline concentration (ug/m3)             23.0


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)               2.1
  Corresponding current concentration (ug/m3)               7.9
  Corresponding baseline concentration (ug/m3)              5.8


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)               6.7
  Corresponding current concentration (ug/m3)              30.4
  Corresponding baseline concentration (ug/m3)             23.7


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for LOSTWOOD NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  9
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)               2.1
  Corresponding current concentration (ug/m3)               7.5
  Corresponding baseline concentration (ug/m3)              5.4
```

CALMET-CALPUFF Predictions for Year 2002-2003 Emissions Without CONAI Sources

Results for MEDICINE LAKE NWA

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              6.8
  Corresponding current concentration (ug/m3)             17.2
  Corresponding baseline concentration (ug/m3)            10.4
```

```
CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              1.4
  Corresponding current concentration (ug/m3)              4.3
  Corresponding baseline concentration (ug/m3)             2.9
```

```
CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              2.9
  Corresponding current concentration (ug/m3)             12.3
  Corresponding baseline concentration (ug/m3)             9.4
```

```
CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for MEDICINE LAKE NWA
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  1
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              0.4
  Corresponding current concentration (ug/m3)              4.6
  Corresponding baseline concentration (ug/m3)             4.2
```

```
CALMET-CALPUFF Predictions for Year 2002-2003 Emissions Without CONAI Sources

Results for FT PECK RESERVATION



CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              5.8
  Corresponding current concentration (ug/m3)              9.7
  Corresponding baseline concentration (ug/m3)             4.0


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S&T          Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              1.5
  Corresponding current concentration (ug/m3)              5.7
  Corresponding baseline concentration (ug/m3)             4.1


CALMET-CALPUFF predicted 3-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              4.5
  Corresponding current concentration (ug/m3)             14.5
  Corresponding baseline concentration (ug/m3)            10.1


CALMET-CALPUFF predicted 24-HOUR SO2 deterioration for FT PECK RESERVATION
Source scenario: WITHOUT sources granted certification of no adverse impact by a FLM

Deterioration gaging method:  PAIRED IN S ONLY       Meteorological Data: RUC2d
                                                        YR 2002
Total no. receptors in Class I area =  4
  Number of receptors with at least one exceedance         0
  Number of receptors with two or more exceedances         0

HSH deterioration among all receptors (ug/m3)              1.9
  Corresponding current concentration (ug/m3)              5.4
  Corresponding baseline concentration (ug/m3)             3.6
```

BLANK PAGE